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**HOW TO FAKE IT ON FACEBOOK**  
The six scientific secrets of social networking success



**Alice Roberts**  
BBC presenter  
reveals the biggest  
Ice Age monsters

**Inside  
your mind**  
The new brain map that  
shows how you think

# FOCUS

SCIENCE AND TECHNOLOGY

sciencefocus.com

ISSUE 255 / JUNE 2013 / £3.99

## BLACK HOLE FEEDING FRENZY

The cosmic event of the  
century is about to begin

**24** mind-bending  
answers to all  
your burning  
questions

SPECIAL REPORT



## THE FUTURE OF FOOD

- Lab-grown beefburgers
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- Purple GM tomatoes
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# WELCOME TO FOCUS



THE HORSEMEAT SCANDAL made me think about my diet, and I made some modest changes. But the world may soon be forced to make even bigger ones, faced with a rising population and pressure on agriculture. So what will we be eating in 10 or 20 years' time? We take a look at likely dishes of the future on p52.

If you feel any hunger pangs, that's nothing compared to the nearest

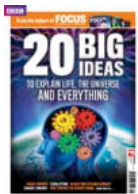
supermassive black hole to us – the one at the centre of our Galaxy. It's about to eat a cloud of gas that's three times the mass of the Earth. Only powerful telescopes will be able to see it happening, but it will reveal much we didn't know about how these celestial monsters digest matter. Paul Sutherland tracks the gas cloud's inevitable doom on p36.

While black holes don't give much away, we have a tendency to do the opposite on social networks like Facebook. But what do our profile and posts actually say about us, and can we 'fake' the information to present ourselves in a better light to friends and prospective partners? Psychology writer Jeremy Dean posts the latest research on p45.

Finally, we'll be at the Cheltenham Science Festival this month, so do stop by our stand if you're going. You'll find more on the festival on p96. Until next issue,

Graham

Graham Southorn, Editor



**PS** Our fantastic new bookazine **20 BIG IDEAS** is on sale now: [www.buysubscriptions.com/20bigideas](http://www.buysubscriptions.com/20bigideas)

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## APPEARING IN THIS ISSUE...



**Rita Carter**

The brains behind books such as *Mapping The Mind* and *Exploring Consciousness*

was the perfect writer to explain the latest results from the Human Connectome Project. It's mapping the brain in unprecedented detail (p74).



**Jeremy Dean**

The man behind PsyBlog and the author of *Making Habits*, *Breaking Habits*

tackles the fascinating world of Facebook profiles. If you want to give the online you a popularity boost, look no further than p45.



**Hannah Devlin**

Hannah tackles all manner of topics in her role as science editor of *The Times*.

This month she chews over the future of food. Find out what culinary delights await you in 10 or 20 years' time on p52.



**Paul Sutherland**

The long-time astronomy writer, is fascinated by everything to

do with black holes. This month his luck was in, as he reports on a giant gas cloud about to journey into the unknown – see p36.



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## SUBSCRIBER BONUS

On p32, **Prof Alastair Gunn** from Jodrell Bank Observatory discusses the future of radio astronomy



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*Focus* (ISSN 0966-4270) is published 13 times a year by Immediate Media Company Bristol, 9th Floor, Tower House, Fairfax Street, Bristol BS1 3BN, UK. Distributed in the US by Evergreen Marketing, 116 Ram Cat Alley, Suite 201, Seneca, SC 29678-3263. Application to mail at Periodicals Postage prices pending at Seneca, SC and additional mailing offices. POSTMASTER: Send address changes to *Focus*, PO Box 669, Selmer, TN 38375-0669.

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# BLACK HOLE FEEDING FRENZY

A large, vibrant image of a black hole with swirling purple and blue gas, serving as the background for the main title. The image is a high-quality astronomical photograph showing the intense gravitational pull of a black hole, with gas and dust being drawn in and illuminated by the surrounding accretion disk.



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# MegaPixel







## Hole lot of diamonds

AT 525M DEEP, five Statues of Liberty could fit end to end into this monstrous hole. This is the world's largest open-pit diamond mine and it has been dug in the town of Mirny in Eastern Siberia. The downwards flow of air into the mine is so large that helicopters are banned from flying over it.

The development of the Mir Mine began in 1957, two years after Soviet geologists found traces of a volcanic rock called kimberlite in the region, often associated with diamonds. "Diamonds themselves are formed under high pressures at least 120km below the surface," says Professor John Ludden,

Executive Director of the British Geological Survey. "However, they can be brought towards the surface by deep, explosive volcanic activity. These explosions create tubes of magma that rip their way through diamond-bearing rock, transporting the diamonds upwards before solidifying into carrot-shaped 'pipes' of kimberlite. The Mir mine sits right on top of one of these pipes."

The mine was permanently closed in 2011, but during its peak in the 1960s it was churning out around 2,000kg of diamonds every year.

PHOTO: AAPOCA ALROSA









## The frozen frontier

IT LOOKS LIKE a settlement on Europa, an icy moon orbiting Jupiter. But this futuristic building is actually much closer to home, in the Antarctic.

Halley VI is a science research centre run by the British Antarctic Survey (BAS) at the bottom of the Earth. It's a string of eight modules, each of which can be relocated by towing it across the ice on skis. This is a vital feature because the station sits on the Brunt Ice Shelf, which is flowing into the sea at a rate of 400m per year. What's more, each module has hydraulic legs

so the station can be raised above the snowdrifts that buried its predecessors.

"The module you see in the foreground has an observation deck," says Dr Anna Jones, a BAS atmospheric chemist. "Inside there's a spectrophotometer that takes measurements of the ozone layer - it's similar to the instrument that enabled Halley scientists to discover the ozone hole in the 1980s. Our long-term measurements are crucial for understanding how Antarctica's atmosphere and climate are changing."

PHOTO: BRITISH ANTARCTIC SURVEY











**MegaPixel**

## Elusive beauty

**THE BLUE JELLYFISH**  
(*Cyanea lamarckii*) cuts quite a dash in the waters around the UK. "It's a very unique colour," says Dr Tom Doyle, a marine biologist at University College Cork. Despite its captivating appearance, there's a lot that's not known about this ethereal creature.

"The blue jellyfish is actually one of the least studied large jellies," says Doyle. The lack of research can be chalked up to the fact that it is far less abundant and far less poisonous than its relatives. While the large lion's mane jellyfish routinely hospitalises swimmers, the blue jellyfish, at just 30cm wide, gives stings no more severe than a nettle patch.

Genetic and tracking studies could answer a few intriguing questions, such as why the blue jellyfish is also found in the waters off Japan, as well as in the UK, but not anywhere in between.

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Letters may be edited for publication

## MESSAGE OF THE MONTH



## Born to lead

I really enjoy your magazine each month – it always gives me something new to think about. But your short article on ‘Leadership in your genes’ (April, p32) really scared me!

It was this sentence that did it: “Employers could one day run tests on applicants to see if they have leadership potential.” My imagination immediately leapt to a dystopian future where human beings are grouped according to their gene pool. Alongside the ‘leadership gene’, will the ‘I’m sorry but you’ll never get on in life gene’ also be discovered?

I was more reassured when I read the UCL website, where Dr De Neve noted: “Our work also draws attention to the ethical issues surrounding the use of genetic tests for leadership selection and assessment, and that we should seriously

consider expanding current protections against genetic discrimination in the labour market. If we really want to understand leadership, we must study both nature and nurture.”

Leaving aside the ethics and potentially frightening consequences, I feel that an awful lot of caution needs to be exercised here about what has been found. Are the people in leadership roles actually good leaders? Have scientists actually found the ‘I’m okay with trampling on people gene’ or the ‘I’m good at blagging my way through interviews gene’?

In short, it is fascinating but clearly early days and I hope a long way from the statement in your article that “employers could one day run tests on applicants to see if they have leadership potential”.

**Helen Carpenter, London**

## A question of free will

I was reading the article ‘Upload your brain’ (April), and it really got me pondering the possibilities that lie ahead within the field of neuroscience. Perhaps one of the main enigmas about our species is whether we really do have free will. An experience is just a flow of electrical impulses that travel through a complicated maze of neurones and neural connections within our brain, all triggered by external stimuli.

Aren’t our choices shaped by our experiences? In theory, once external stimuli trigger an electrical pulse, you could track precisely where the electrical impulses will travel within the brain if its structure is precisely known. Thus you could determine where they will end up and ultimately what our choices and decisions will be. Do we defy nature by being free from deterministic laws, or is our understanding on the human brain just limited?

It would be fantastic if The Human Brain Project shed some light on these once-philosophical ideas.

**Matthew Whelan, Sheffield**

*For the latest on the Human Connectome Project, which aims to map connections in the brain, see p74. –Ed*

## Sex on the brain

Arthur Clarke, in a story many years ago, foresaw the appeal of pornography on TV, although he went no farther than playing with the shadows cast by the erotic carvings on a Cambodian temple.

Uploading emotions and experiences for other people to share opens up a whole new industry. It might be possible to share the participants’ emotions during an interview with a headline superstar, the feelings of a sportsman setting a new record or a footballer taking part in a game. What a market there would be.

But what about recording emotions during sex? How much would you pay to have sex, even second-hand (could you tell the difference?) with some sex goddess of the silver screen? The mind boggles. Just put a chip in the machine and plug yourself into a cable. I would buy shares!

**Pat Ladd**

**Write in and win!**

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The Talpiot Tomb in Jerusalem  
- Jesus's resting place?

## The search for Jesus

In the April issue, @A183white says on p17 that the finding of Jesus or Adam would top the discovery of Richard III. In February 2007, Simcha Jacobovici and Charles R Pellegrino published a book telling of the discovery of the Talpiot Tomb and how this is supposedly the tomb of Jesus Christ and his family. As you would expect, a discovery of this nature is mired in controversy and argument. Is it the tomb of Jesus Christ, his wife and children, or a case of the authors finding connections that are not really there to create a story?

**Kevin Lewis, Wiltshire**

## Fat fighters

In April's 'Q&A' section I believe a question on p68 has been answered incorrectly in two ways. The question is whether fat supplies would increase the time it takes a person to starve to death. First, without water, a fat and normal person would die after a similar amount of time; fat stores would be quite marginal in the survival. Second, the answer states that ketones can be created from fat stores to fuel the brain, which is correct. However, it goes on to state that a starving brain needs glucose from muscle tissue breakdown. This is true, but not the full story. Initially, the body will break down muscle to fuel the body/brain, but after a few days, once ketogenesis kicks in, muscle breakdown stops. The body knows that if it continues to break down muscle for too long, we'd be stuffed!

However, within adipose (fat) tissue, there are stores of metabolic fluid. This delays dehydration. A thinner person would have less of this, and thus succumb to dehydration and death sooner.

**Jamie Pope**

**Luis Villazon replies:** *Obviously without food or water, a person will die of thirst long before they die of starvation. While you are right that muscle breakdown slows down during prolonged starvation, my understanding is that it does not stop completely. I refer readers to Biochemistry by Berg, Tymoczko and Stryer: even after 40 days of complete food starvation, the brain still uses 40g of glucose per day, along with 100g of ketone bodies. That glucose*

*can only come from muscle breakdown. The brain's requirement for glucose means it is possible to starve to death even when you have some body fat remaining.*

## Quantum smell

I was interested in the article on the work of Dr Luca Turin, suggesting that molecular vibrations are responsible for our sense of smell (April, p31). Back in the 1950s, RH Wright suggested, on quantum grounds, that molecular vibrations were involved in odour perception. Throughout the 1960s and 1970s, there was much discussion of the relative merits of the vibration theory and the 'lock-and-key' model. The latter won out because of its conceptual simplicity.

**Ron Gardner, Ludlow**

## Chaotic radiation

Re: 'Chaos reigns' (April, p75), are apparently random events like the decay of radioactive elements actually chaotic and therefore deterministic (although we cannot predict them because we have no way of knowing the initial conditions)?

The implications of this would be enormous because, ultimately, how could there be free will?

**Geoff Dunwell, Maidenhead**

**Adam Kucharski replies:** *Quantum mechanics assumes the decay of a single particle is truly random. Of course, this doesn't prove that there isn't some hidden, chaotic process driving radioactive decay. But if there is one, we haven't found it yet.*

## YOUR COMMENTS ON FACEBOOK AND TWITTER

On facebook.com/sciencefocus, we asked:

**NASA has ruled out a return to the Moon. Is this the right thing to do?**

**Gerard Hand** Is there any point going to the Moon again?

**Jamie Hetherington** I reckon some private company might go instead.

**Paul Mullins** All the documentaries I have just watched about holiday resorts and bases on the Moon - talk about filling my head with nonsense.

**Zac Taylor** I'd rather they focus on getting to Mars!

**@samuelpeepses** I think it will be the Chinese who'll take up the gauntlet. The prestige would be immense.

**@Hippo\_Critic** Unless it's the start of a permanent base. We've already done the 'one small step'. It's time for the 'giant leap'.

# FOCUS

SCIENCE AND TECHNOLOGY

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Audit Bureau of Circulations  
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Annual subscription rates (inc P&PO):  
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£54.96; Rest of World Airmail £59.99.

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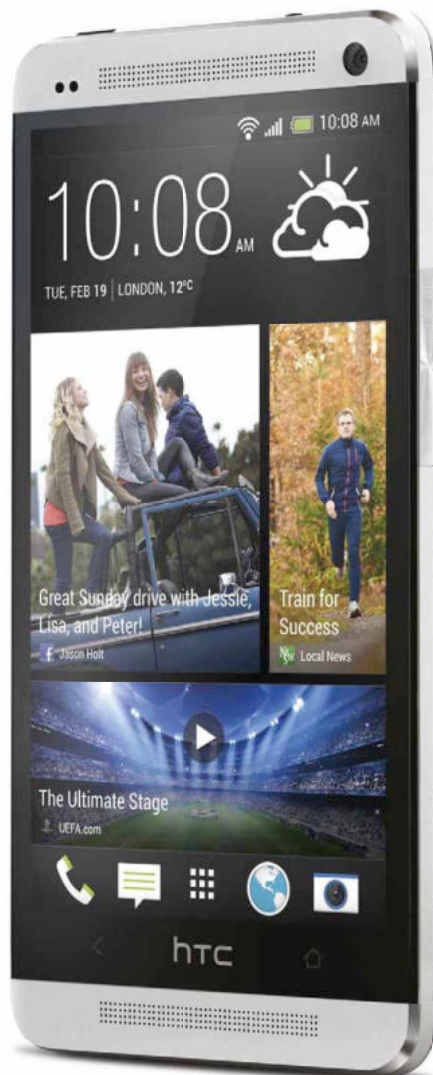
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# DISCOVERIES

News and views from the world of science

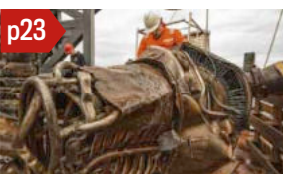
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## FROG UNFROZEN

Are we on the brink of reviving an extinct species for the first time?

p23



## ROCKETS RESCUED

Amazon boss funds retrieval of Saturn V rockets from the bottom of the ocean

p24



## NO SPECS PLEASE...

New screen promises 3D TV without the bulky glasses

### THE BIG STORY

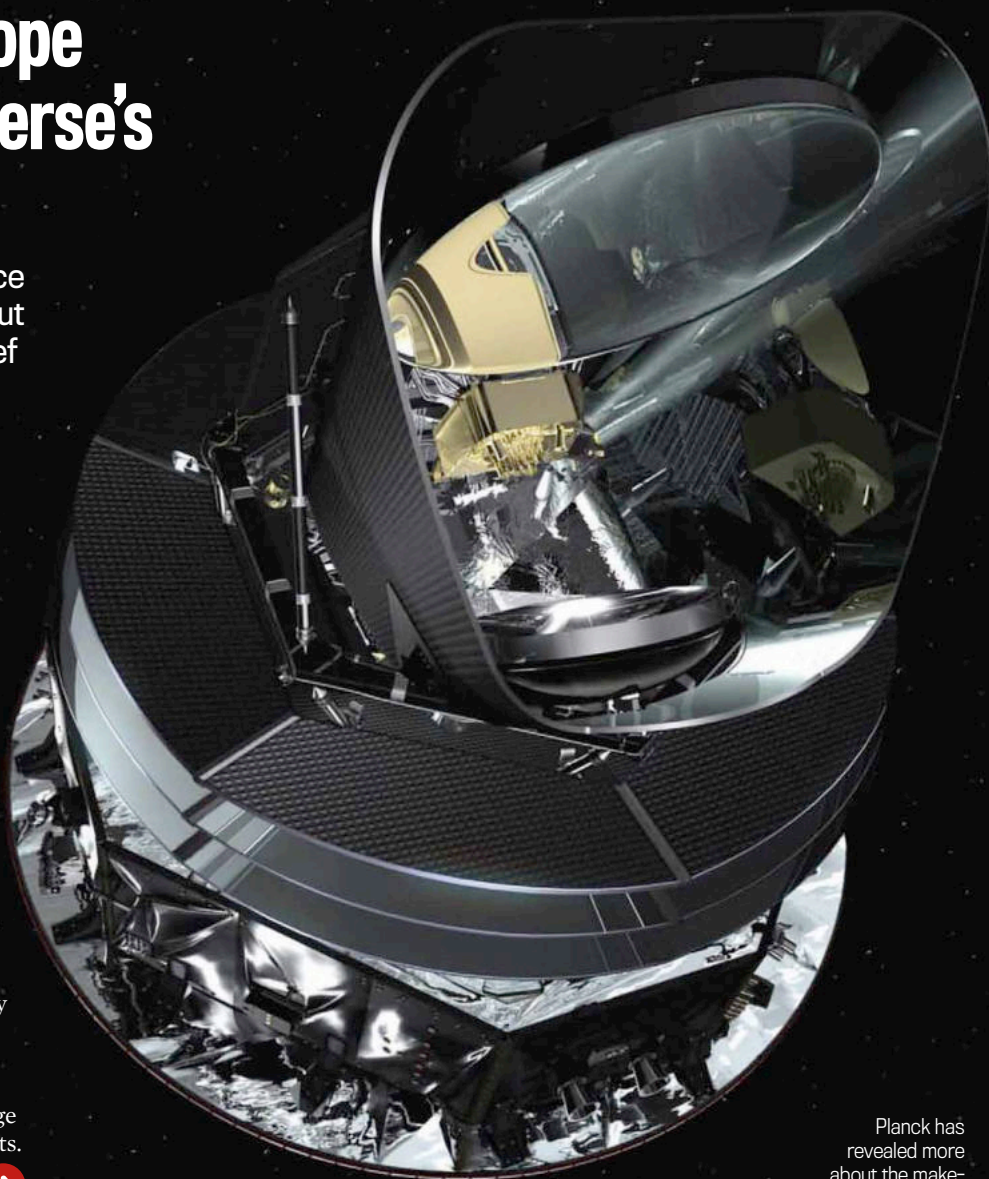
## Space telescope exposes Universe's mysteries

Planck maps ancient space in unprecedented detail but also brings into sharp relief what we don't know

THE UNIVERSE IS 100 million years older than we previously thought. That's one of the findings from the most detailed ever map of the oldest light in the Universe generated by the European Space Agency's (ESA) Planck satellite.

Launched in 2009, Planck is a space observatory creating a picture of the first light produced after the Big Bang, known as the cosmic microwave background. Fluctuations in the temperature of this light reveal the distribution of matter in this early Universe and allow astronomers to work out how it has evolved to what we see today.

Now the first 15 months of CMB data collected across the whole sky by Planck have been released. As well as refining estimates of the Universe's age from 13.7 to 13.8 billion years, the results also change our understanding of its ingredients. We now know that there is more normal matter and dark matter, ➔



Planck has revealed more about the make-up of the cosmos

PHOTO: ESA





# ANALYSIS

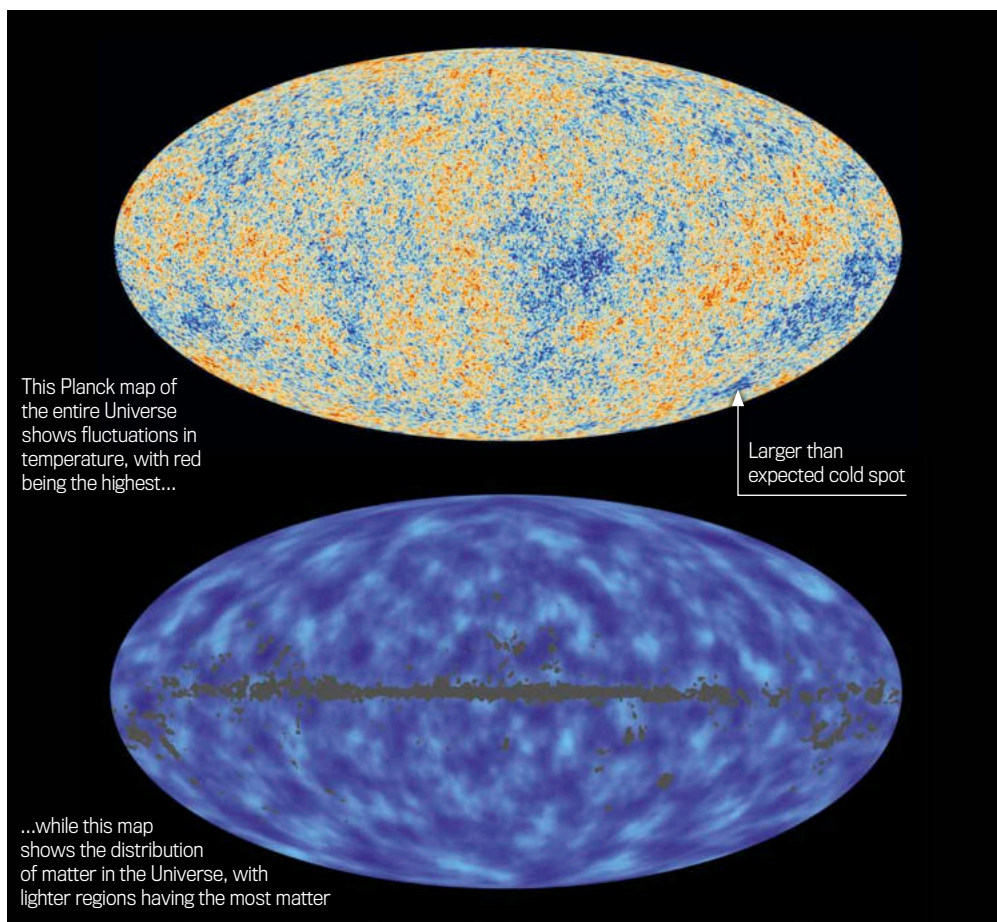
**Prof Edward Wright**

Cosmologist at the University of California, Los Angeles

“PLANCK’S RESULTS ARE consistent with what previous experiment WMAP had, but are more accurate. Both the amount of matter and dark matter are better measured, with a fraction of a per cent accuracy instead of two per cent.

The anomalies that have been widely discussed aren’t new. For example, the difference Planck sees in the size of the temperature fluctuations in the north and south hemispheres of the sky is now better measured, not bigger. However, there’s still a lot we don’t understand. The accuracy with which we have measured the amount of dark energy in the Universe has improved, but we still don’t understand why it exists.

What I would like to see an explanation as to why we have this amount of dark matter and why we have a certain amount of dark energy. Those are things that we don’t understand.”



the invisible stuff whose presence we can only deduce by the effects of its gravity, than we thought. Normal matter is up by 0.3 per cent, while dark matter is up by nearly 3 per cent. But there’s correspondingly less dark energy, the mysterious force pushing the Universe apart.

Planck can see fluctuations in the CMB with greater resolution than any experiment before it, including NASA’s Wilkinson Microwave Anisotropy Probe (WMAP). It measures the Universe at nine wavelengths, from microwaves to the very far infrared.

“The more wavelengths you measure it at, the more you can disentangle light from the Galaxy from the light from the Big Bang,” says Dr Joanna Dunkley, a Planck scientist based at the University of Oxford.

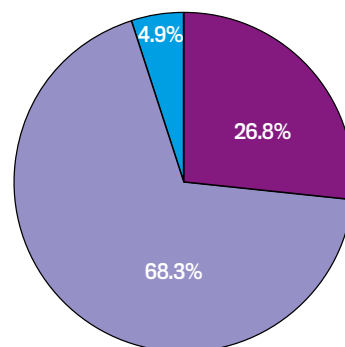
The age, contents and other traits of the Universe are encapsulated in the ‘standard model of cosmology’. Planck’s findings largely agree with the model’s predictions: “What Planck sees is a very simple Universe,” says Dunkley. But there are some features of the map that are harder to explain. The standard model predicts the CMB will largely be the same across the sky, but there’s a difference in the temperature fluctuations seen within the two hemispheres. A cold patch in the sky is also much larger than expected.

“It could be a hint that there might be something wrong with our idea of what went on right after the Big Bang,” says Dunkley.

Planck is still scanning the skies and its complete results will be released in 2014.

**KELLY OAKES**

## NEW COMPOSITION OF THE UNIVERSE



Proportions of **NORMAL MATTER**, **DARK MATTER** and **DARK ENERGY** based on new Planck data

## TIMELINE

A history of the cosmic microwave background

**1964**

Arno Penzias and Robert Wilson accidentally discover cosmic microwave background (CMB) radiation while at Bell Labs in New Jersey, after ruling out radio noise from New York or pigeon droppings as the culprit.

**1983**

RELIKT-1, a Soviet CMB experiment, launches and observes the sky for six months. It is the first space-based experiment to measure temperature fluctuations in the CMB.

**1989**

NASA’s Cosmic Background Explorer (COBE) launches. It measures the CMB in great detail and provides more support for the Big Bang theory.



**1993**

Two separate ESA mission proposals, COBRAS and SAMBA, are combined. In 1996, the new project is renamed Planck and construction begins ahead of its 2009 launch.

**2001**

COBE’s successor, the Wilkinson Microwave Anisotropy Probe (WMAP), maps the CMB at greater resolution, confirming many cosmological theories about the early Universe.

**2013**

The Planck mission’s first all-sky map of the CMB is released, giving us the most detailed baby picture of the Universe yet and enabling cosmologists to refine their theories even more.



The southern gastric-brooding frog: like Arnie, he'll be back...

## 🕒 1 MINUTE EXPERT

### Kawazulite

#### What's that?

It's a mineral that occurs naturally in the Earth's crust. German physicists recently showed that a sample from the Czech Republic has the odd property of being an electrical conductor on the outside and an insulator on the inside.

#### How does that come about?

Inside the mineral, electrons move in circular motions, preventing them from flowing through the material. But at the surface they are compelled to skip along the material's edge, and so can conduct electricity.

#### So why is it in the news?

Such 'topological insulators' have been synthesized in the lab, but this is the first time the phenomenon has been spotted in a natural sample. These insulators could give us faster computers in the future.

#### How might that work?

One property of electrons is their spin. This can have only two values – 'spin up' or 'spin down'. In the conducting layer of the material, spin up electrons move in one direction, while spin down electrons move in the other. This results in a 'spin current' – a flow of electron spin rather than charge. This could open the door to 'spin transistors' that are much faster than the transistors used in our computers today.



## Biology

# Leap in cloning could resurrect bizarre frog

**T**HE IDEA CAPTURED the public's imagination thanks to *Jurassic Park*, and now a once-extinct animal may actually be brought back to life using cloning technology. Australian researchers have produced embryos of a frog that disappeared from the wild in 1979, and say it won't be too long before a fully developed animal is hopping about again.

Native to Australia, the southern gastric-brooding frog (*Rheobatrachus silus*) had a bizarre reproductive technique. Females swallowed fertilised eggs, brooded the young in their stomachs and then gave birth to fully-grown froglets through their mouths. Thankfully, a few samples of the frog were kept in a scientist's freezer and some of the cells were left relatively unharmed by ice crystals. Researchers led by Prof Mike Archer at the University of New South Wales in Sydney took donor eggs from the related Great Barred Frog, inactivated the nuclei and

replaced them with nuclei from the extinct frog. At the TEDxDeExtinction conference in Washington DC, the 'Lazarus Project' team revealed that they managed to produce embryos, although none survived.

"We are watching Lazarus rise from the dead, step by exciting step," says Archer. "We're increasingly confident that the hurdles ahead are technological and not biological, and that we will succeed."

Fellow team member Simon Clulow told *Focus* he thinks they could have a tadpole within two years. Other groups around the world are also trying to revive extinct animals – Russian and South Korean scientists have their sights on the woolly mammoth.

"We urgently need gene banks for the animals that are vanishing," says Clulow. "We need to have that broad spectrum of genetic diversity ready to go when we are able to reintroduce it back into the world."

**ZOE CORMIER**

## WHO'S IN THE NEWS?

### Fred Turner

A 17-year-old named as the UK's Young Engineer of the Year

Fred (front) with his brother Gus and the 'DNA photocopyer'



#### ◉ What did he say?

The teenager said he built a DNA sampling machine in his bedroom to find out why he has straight brown hair but his younger brother, Gus, has ginger curls. "After years of jokes from my friends saying me and Gus have different dads, I built the machine to test once and for all why my brother is ginger and I am not."

#### ◉ So what did he do?

Fred, who lives in Brighouse, West Yorkshire, cobbled together what he describes as a 'DNA photocopyer' from items he found around the house, including a video player. He took a swab of cells from his brother's cheek before putting the sample into his machine, which uses a centrifuge to separate the DNA from the cells

in a process that takes around two hours. Fred then sent the sample off to a lab to be tested.

#### ◉ What did the test show?

"I discovered that Gus has a mutated gene, which explains why he is ginger and I'm not," said Fred, who will be starting an undergraduate course in biochemistry at Oxford University this September.



## HOT TOPIC



Lockheed Martin plans to mine the seabed for valuable minerals

# Should we mine the seabed?

**T**HE STREETS OF London may not be paved with gold, but sea floors around the world are lined with precious metals. Now a UK company has announced its plans to set about harvesting some of them.

Lockheed Martin UK, the British arm of the US defence giant, says it wants to prospect for the minerals on the floor of the Pacific Ocean, 1,500km southwest of Mexico, to see if it is able to bring them to the surface. Its targets are polymetallic nodules: rocky lumps that litter the seafloor and that are rich in valuable metals such as copper, cobalt and manganese.

About the size of golf balls and potatoes, nodules are believed to form over millions

of years as concentric layers of minerals from surrounding seawater build up around a core of something hard, from a speck of rock to a shark tooth. They are expensive to harvest, but some now think the growth in demand for metals from nations such as China could make their retrieval worthwhile.

Lockheed, which would carry out the mining through its subsidiary UK Seabed Resources, has a licence to prospect an area measuring 58,000 square kilometres – nearly three times the size of Wales. It has not released details of how it would mine the site but says it hopes to start in five to six years, once it has completed technology tests and environmental studies. Some

### WHAT DO YOU THINK?

Let us know your opinions at [twitter.com/sciencefocus](https://twitter.com/sciencefocus) using the hashtag #hottopic, as well as [facebook.com/sciencefocus](https://facebook.com/sciencefocus) and our forum [sciencefocus.com/forum](https://sciencefocus.com/forum)



**mrkendo:** "The whole food chain starts at the seabed level. The organisms and sea life at those levels are the food chain for the next level of marine creatures and that level becomes the food chain for the next level and so on, all the way to the human race."



**Diablo:** "The oceans are already so polluted with chemicals and plastics that it probably won't make much difference to food production."



**MikeG:** "Just mining or dredging would have a very localised effect in my inexperienced opinion, provided that no chemicals are used in the extraction. We probably cause far more harm with the millions of tonnes of plastic and other rubbish we dump in the oceans every year."



**David Kelly:** "Well it's either there or space – the population is expanding and resources are needed!"



**Sophie Baggs:** "No, there are so many as-yet-undiscovered life forms in the deep sea. We should not risk losing them just for wealth for humans."



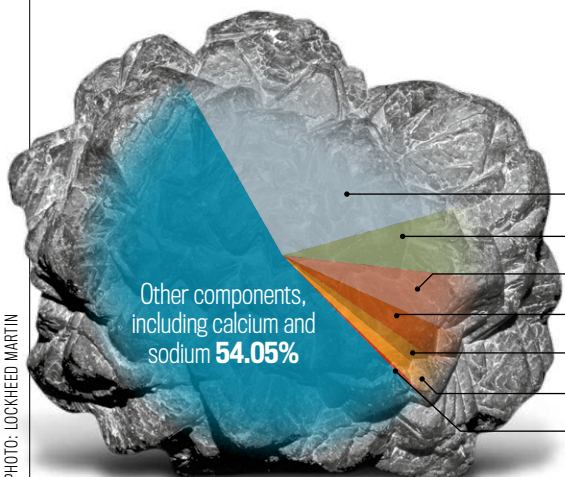
**Danny O'Shaughnessy:** "It is a huge risk, especially to wildlife. More research should be done before full scale mining; even a trial would be better."

scientists suggest the nodules could be piped to the surface, while others say they could be processed at depth and just the precious metals harvested.

Far more controversial is the related idea of mining hydrothermal vents – hot water chimneys – on the seafloor. This technique would see the uppermost layer broken up and carried away, but the practice is not understood to be part of Lockheed Martin's plans in the Pacific.

"It is important to understand that there is a big difference between mining nodules which lay on the sea floor on abyssal plains, and the mining of hydrothermal vents," says Dr John Luick, an oceanographer at the South Australian Research and Development Institute. "The vents are like oases of biological activity. Compared to the abyssal plains, the areal extent of vent systems is also relatively limited. So it is conceivable that they could be completely razed in a matter of decades if miners were given carte blanche access."

**DAVID ADAM**



## What's inside a polymetallic nodule?

**Manganese 29%**

**Iron 6%**

**Silicon 5%**

**Aluminium 3%**

**Nickel 1.4%**

**Copper 1.3%**

**Cobalt 0.25%**

Other components,  
including calcium and  
sodium **54.05%**



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# PATENTLY OBVIOUS

Inventions and discoveries that will change the world with James Lloyd



## Wheeling beneath the waves

BRITISH ARTIST SUE Austin's graceful antics on her underwater wheelchair as part of the Cultural Olympiad last summer captured many people's imaginations (if you missed it, just search YouTube for 'underwater wheelchair'). But now Austin, a wheelchair user since 1996, wants to give others a taste of the action.

Her patent application describes how her underwater wheelchair design could consist simply of a standard wheelchair propelled by two battery-powered diver propulsion vehicles. The

operator would then steer the chair using two acrylic 'wings' attached to the underside of the footrests, while an extra hand-operated fin would be located at the rear. There would also be an option to include 'sip-puff' controls or tongue switches, for the quadriplegic or the limbless. An inflatable buoyancy bag would enable the diver to compensate for changes in pressure, preventing the chair from rising or sinking too much.

**Patent application number:** GB 2494309

## Drop-proof gadgetry

IMAGINE SHELLING OUT several hundred pounds on a smart new phone or laptop, only for it to drop on the floor and smash into pieces. But don't worry about it for too long, because Apple has come up with a system that would slow a gadget's fall and protect the most vulnerable parts, such as the screen. Sensors such as an accelerometer would detect when your iPhone or MacBook is in free fall and alert a processor that would initiate remedial action.

Apple is exploring a number of damage-mitigating techniques. One is for thrust supplied by compressed gas to rotate the device so it lands on an edge. An airfoil could spring from a surface to reduce the object's velocity, while the device's buttons could be retracted to keep them safe.

What's more, the device might also function as a kind of black box recorder, storing information about any falls a device suffers to help its manufacturers design more robust gadgets in future.

**Patent application number:** US 20130073095



## Hands-free home

IN A NEW patent application, Google describes how its Glass augmented reality specs will superimpose virtual controls onto household objects. For example, the glasses' built-in camera could detect when you're in front of the fridge, overlaying a virtual temperature button that can be operated with hand gestures. Or the display might show a message such as 'Open garage door?' when it detects you're pulling into your driveway.

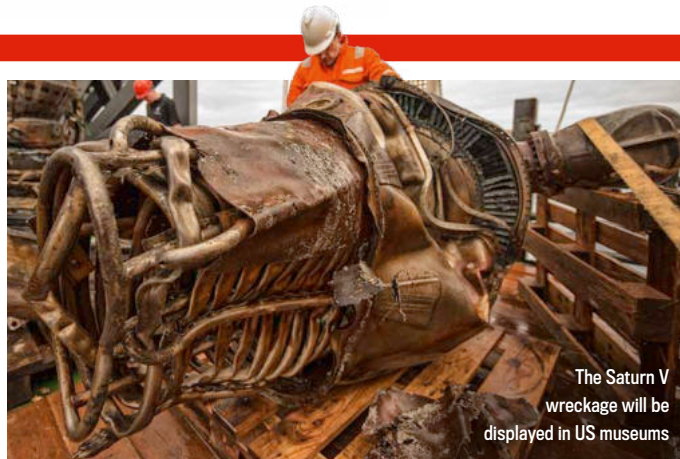
**Patent application number:** US 20130069985

## Rocket science

### Saturn V engines rescued from the deep

THEY LIFTED MEN towards the Moon, but the Saturn V rockets that powered NASA's Apollo missions in the 1960s and 70s have spent the last few decades silently decaying at the bottom of the Atlantic. Now, in an expedition funded by Amazon founder Jeff Bezos, two of them have been hauled from the bottom of the sea.

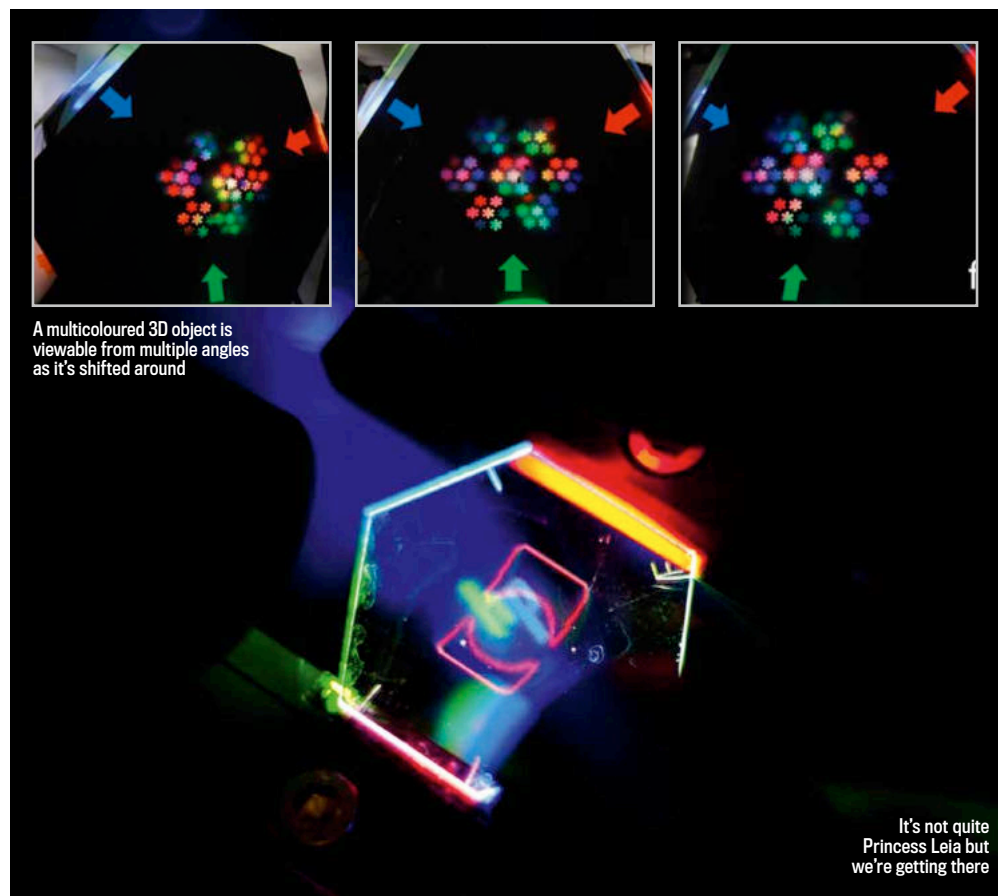
The engines will be restored before going on public display at museums in the US. It's not known which mission the engines are from, as their serial numbers have been worn away, but restoration may reveal more. There's still a chance that these are the very engines that lifted Armstrong, Aldrin and Collins to the Moon in 1969.



The Saturn V wreckage will be displayed in US museums

PHOTO: BEZOS EXPEDITION ILLUSTRATOR: ROBIN BOYDEN





A multicoloured 3D object is viewable from multiple angles as it's shifted around

It's not quite Princess Leia but we're getting there

## Consumer technology

# Screen gives 3D picture without specs

**W**ATCHING THE LIKES of *Prometheus* or *Life Of Pi* in 3D certainly adds an extra layer of realism to the experience – the downside being the clunky pair of glasses you have to wear to get it. But a new screen technology could be about to remove the need for them altogether.

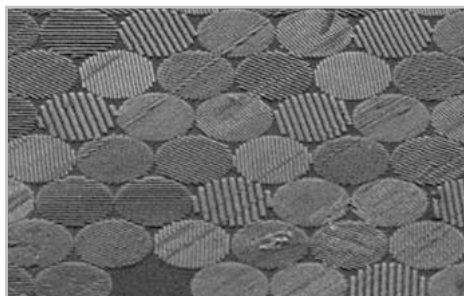
Developed at Hewlett-Packard Laboratories in California, the system can beam slightly different images to each eye – the basic requirement for a 3D effect – using a clever technique for directing the light emitted by each pixel. The secret is a new kind of backlight that's made from a thin glass slide etched with tiny grooves that are invisible to the naked eye. When light from LEDs is shone sideways through the slide, it scatters off each groove in a specified direction – so each eye gets a slightly different perspective on an image. The prototype screen has been built into a smartphone, but it could soon be scaled up to TV proportions.

"We could see the first applications of this technology within a few years," says physicist

Dr David Fattal, who led the Hewlett-Packard team. "In the more distant future, these displays could be used in any situation where it's important to have a sense of depth, such as a surgeon who's remotely operating on a patient, or a scientist carrying out repairs on a distant spaceship."

Take a look at the prototype for yourself at <http://bit.ly/10zlwKg>

**JAMES LLOYD**



Grooves etched in the backlight of the new screen scatter light, sending subtly different images to each eye

## DIGITAL WORLD

Science on the web

### IT'S OKAY TO BE SMART

[www.youtube.com/itsokaytobesmart](http://www.youtube.com/itsokaytobesmart)



As fans of his Tumblr blog will know, Joe Hanson of It's Okay To Be Smart is an expert when it comes to serving up easily digestible chunks of science. So we were really excited to see that his new YouTube channel offers the same blend of science and 'interestingness', with new videos every other Monday.

### FALSE MEMORY ARCHIVE

<http://falsememoryarchive.com/>

If you have a memory of an event you later discovered didn't take place, the good people at the Anomalous Psychology Research Unit at Goldsmiths College, London, want to hear from you. Selected submissions to their site will be published online and form part of a tour of talks and exhibitions.

### WORLD WIDE TELESCOPE

[www.worldwidetelescope.org](http://www.worldwidetelescope.org)

Fancy a scenic tour of Mars? Want to get better acquainted with Planck's new map of the Universe? World Wide Telescope lets you zoom around the cosmos to your heart's content. There are guided tours if you don't want to go it alone, but the fun really starts when you step off the beaten track...

### HISTORY OF GENETICS

<http://tinyurl.com/cepo99z>

From Darwin to some of the latest genome sequencing results, if you want to find out how our knowledge about genes has grown, we recommend the Wellcome Library's timeline. It's once you start to click on the grey squares that pinpoint specific periods that you realise how rich with information this slick site is.

**KELLY OAKES**





## GRAPHIC SCIENCE

Seeing research differently

### BOOKS REFLECT OUR EMOTIONS

WHEN THE NATION'S happy, the tone of our books is happy and when we're down, our books are generally gloomier. That's the picture painted by new research in which text from millions of tomes has been analysed to chart emotional trends throughout the 20th Century.

British anthropologists analysed phrases that appear in Google's gargantuan Ngram Viewer, a database of words and expressions used in the

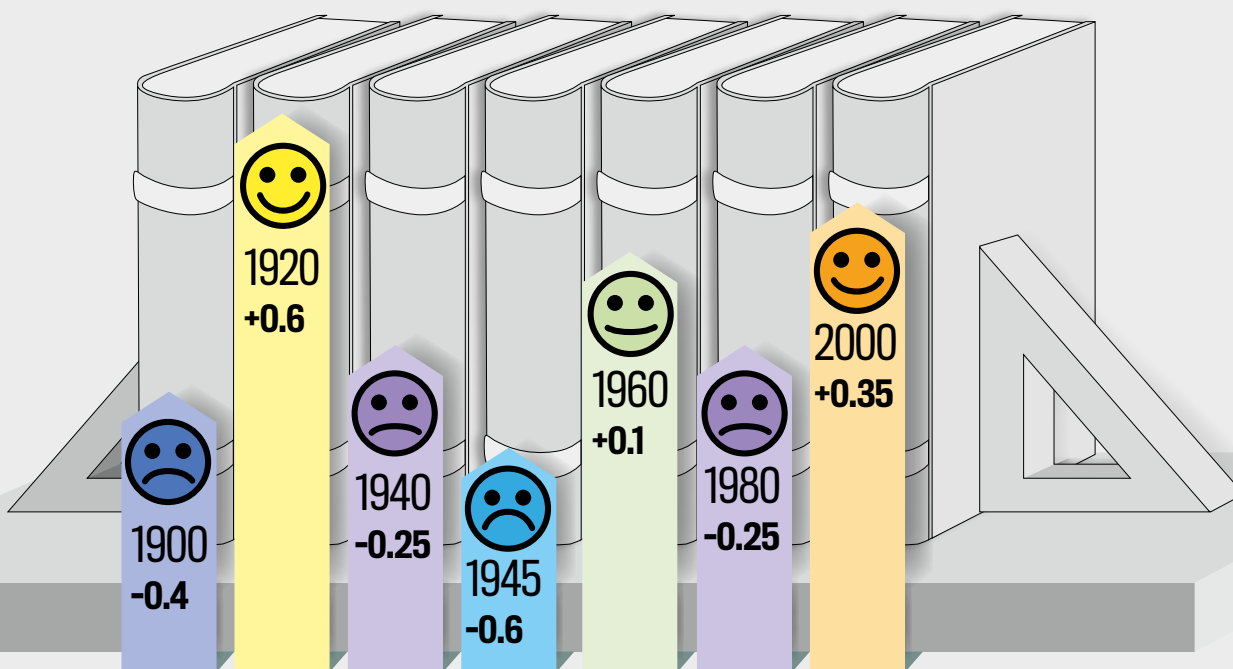
5.2 million books – both fiction and non-fiction – which have been digitised. Led by Dr Alberto Acerbi at the University of Bristol, they 'text mined' the data, picking out phrases expressing emotions and assigning them to categories such as fear, joy and disgust.

A surge in gloominess in books in the early 1940s coincides with World War Two, whereas in the swinging 60s, writers were in a decidedly

more positive frame of mind. Another trend also became clear – since about the 1960s, US books have been much higher in emotional content than British ones.

The research is part of a rising tide of 'cultiromics', the analysis of cultural shifts using digitised texts. Previous research has shown that 'mood words' on Twitter can predict stock market trends.

### UPS AND DOWNS OF THE 20TH CENTURY



Difference between joy and sadness scores (negative figure indicates sadness dominates)

### NEWS IN BRIEF

#### Phew! Higgs is the Higgs

• Physicists at the Large Hadron Collider have crunched more data and confirmed that what they announced as probably the Higgs boson in July 2012 is indeed the Higgs. To make the announcement about this subatomic particle, said to give other particles their mass, the researchers needed to analyse more of its properties, such as whether or not it spins.



The Diamond Light Source accelerator: an important weapon against foot and mouth

#### Diamond cracks FMD

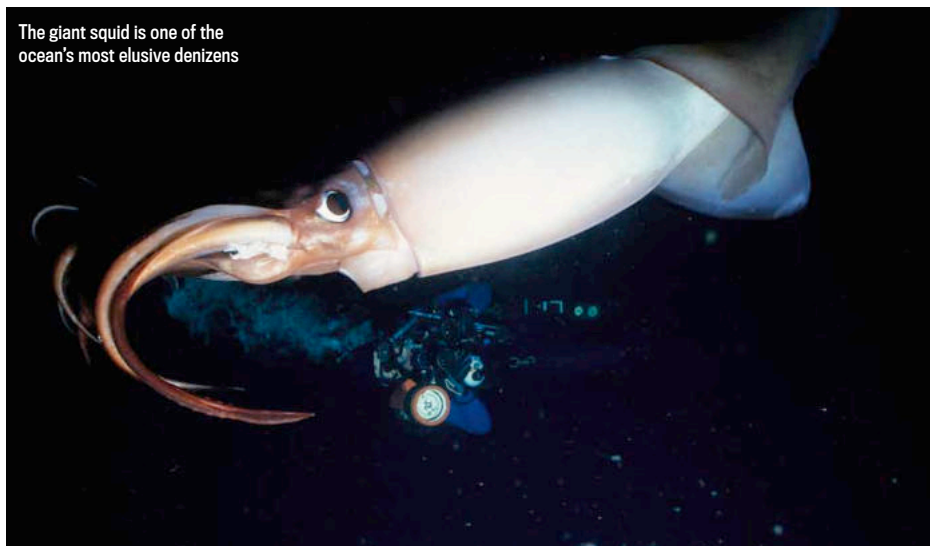
• A new vaccine against foot and mouth disease has been developed that doesn't involve injecting a live virus. Using the Diamond Light Source particle accelerator in Oxfordshire, researchers were able to analyse the outer shell of the foot and mouth virus in unprecedented detail, to ensure a synthetic version is as close a match as possible.

#### Criminal minded

• Research in New Mexico, USA suggests brain scans could identify criminals *before* they commit a crime. Neuroscientists scanned the brains of 96 prisoners just prior to their release. Those with lower activity in the anterior cingulate cortex during a decision-making task were more likely to be arrested following their release.



The giant squid is one of the ocean's most elusive denizens



## Marine biology

# Giant squid almost confined to history

**T**HEY CAN GROW to 13m (46ft) in length and make fearsome predators, yet the giant squid may once have almost become extinct. A genetic analysis of these rare creatures, which live around the world, shows there is shockingly little diversity in their DNA – which shows their numbers may well have drastically dropped at some point.

An international team of researchers got their hands on tissue samples from 43 giant squid – no mean feat given the fact that these deep-ocean dwelling creatures were only seen alive in the ‘wild’ for the first time in 2004. The samples came from dead squid washed up on beaches or floating on the surface, and squid accidentally caught by deep-sea trawlers.

The geneticists then analysed the DNA inside the squids’ mitochondria – the

power plants of their cells – rather than the genetic material inside their cells’ nuclei. They found that regardless of where the squid came from, the DNA was similar. In fact, only one other marine animal, the basking shark *Cetorhinus maximus*, has lower genetic diversity.

Although a near-extinction event in the giant squid is a distinct possibility, PhD student Inger Winkelmann at the University of Copenhagen says nothing can be ruled out at this stage. “It could be that they always had a low population size but then recently expanded for some unknown reason, or maybe they went through a bottleneck at some point – we just can’t really tell yet.”

If there was an extinction event, then its cause is also something of a mystery.

**ZOE CORMIER**

## Neuroscience

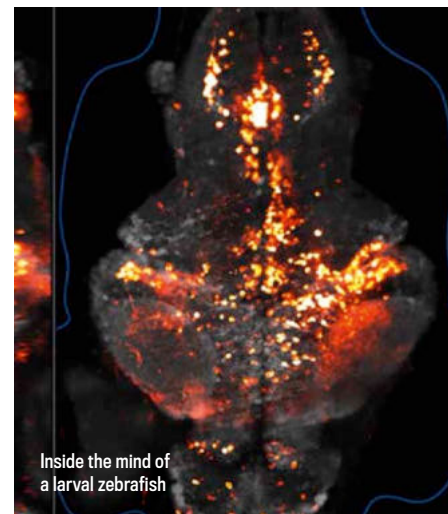
### Brain chatter caught on film

IT MIGHT LOOK like an aerial view of a city’s streetlights, but the picture below is actually a snapshot of a larval zebrafish’s brain showing individual neurons firing. The still image has been taken from the first-ever movie of an entire vertebrate brain that shows what’s going on at the level of the individual neuron.

Created by Philipp J Keller at the Howard Hughes Medical Institute in Virginia, with colleague and neurobiologist Misha Ahrens, the movie will provide an insight into how different parts of the brain work together. It was made using genetically engineered zebrafish whose brain cells make a protein that fluoresces when they fire. It shows 80 per cent of the fish’s 100,000 neurons. We have only been able to see a few thousand neurons at a time until now.

You can watch the video at <http://bit.ly/ZhFMhp>. For the latest on imaging the human brain, see page 74.

**ZOE CORMIER**



Inside the mind of a larval zebrafish

## NEWS IN BRIEF

### Dark matter found?

• An experiment aboard the International Space Station (ISS) may have spotted dark matter. The Alpha Magnetic Spectrometer, a \$2billion (£1.3bn) cosmic ray detector, has found far more positrons, the antimatter version of electrons, than can be accounted for by known sources. One suggested source is dark matter particles colliding with each other.



### Birds driven to evolve

• Cliff swallows nesting close to busy roads are evolving shorter wingspans to help them dodge traffic, a 30-year study in Nebraska shows. Ecologists have found that the swallows’ average wingspan dropped by 5mm between 1982 and 2012, while the number of birds killed on the roads has been falling. A shorter wingspan is known to make birds more agile.

### Quakes create gold

• Earthquakes are thought to have the Midas touch, creating gold in a flash. Researchers in Australia say tremors cause a sudden drop in pressure inside zigzag cracks that connect fractures in the fault. Any water within these voids is vapourised, depositing materials such as quartz and gold onto nearby surfaces.



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## Materials

## Lighter than air

A lump of carbon aerogel is so light it can rest on a slender grass



**S**CIENTISTS IN CHINA have developed a new material that's so light it can perch on a slender blade of grass without bending it. With a density of 0.16mg per cubic centimetre, the newly-created carbon aerogel is lighter even than air. The wonder material – 12 per cent lighter than the previous record holder, aerographite – is made from a freeze-dried solution of carbon nanotubes and graphene.

The team behind carbon aerogel's development, led by Prof Chao Gao at Zhejiang University, are looking into ways in which it could be used. Clearing up oil spills is one possibility – current oil-absorbing products can take in 10 times their own weight of oil whereas carbon aerogel sucks in 900 times its own weight. It may also be used for sound absorption.

See next month's issue to see whether carbon aerogel makes it into *Focus's* list of 'Ten materials that will change the world'.

ANDY RIDGWAY



## THEY DID WHAT?!

## Women asked to rate attractiveness of naked men

## What did they do?

Over 100 female volunteers were shown naked male bodies and asked to rate how attractive they found them. The computer-generated male figures were projected life-size onto a wall and varied in height, shoulder-to-hip ratio and flaccid penis size.

## So what happened?

The volunteers – staff and students from Monash University in Melbourne and Australian National University

in Canberra – collectively rated the male figures more highly the taller they were, the greater their shoulder-to-hip ratio and the larger their penis.

## What does this tell us?

In their report, the biologists say their findings "directly contradict claims that penis size is unimportant to most females". They add that their results support the theory that female mate choice drove the evolution of the comparatively large human penis.

## WHAT THE PAPERS SAY

## HENRY GEE

The latest from leading science journals



## Neanderthals and Lolcats

**T**HE NEANDERTHALS are everyone's picture of the archetypal cavemen. Tough, stocky and adapted to living in the cold of Europe in the Ice Age without even a hot water bottle, Neanderthals walloped mammoths, wrestled sabre-toothed tigers and could have ripped phone books in half with their bare hands, had such things existed. They also had brains the same size as ours – or in some cases larger.

So how is it that modern humans, in less than 40,000 years, went from living in caves to posting pictures of their cats online, whereas the technological achievement of Neanderthals, in their 300,000 years of existence, was a big fat zero? The answer has more to do with posting pictures of cats than you might think.

In a paper in the journal *Proceedings Of The Royal Society B*, anthropologists Ellie Pearce and Robin Dunbar of Oxford University, with palaeontologist Chris Stringer from the Natural History Museum, show that whereas Neanderthals had big brains, they couldn't devote as much brain volume to actual thinking. Firstly, big bodies need big brains to run them, so Neanderthals would have

used more of their brains for simple housekeeping duties such as breathing and moving. Secondly, Neanderthals had proportionately bigger eyes than modern humans, and eyeball size is strongly related to the amount of brain tied up in visual processing. Because Neanderthals had very large eyes compared with ours, it's a fair bet that their visual system took up more of the brain than it does in modern humans. The researchers speculate that visual acuity would have been at a premium for Neanderthals, who evolved in dimmer, more seasonal northern latitudes.

This work is part of a trend in the study of human evolution showing that intelligence is less about the size of your brain than what you do with it. In another paper in the same journal, Jeroen Smaers and Christoph Soligo of University College London show that changes in the relative sizes of parts of the primate brain have been more relevant to the needs of primates as they evolved than changes in gross brain volume.

So what has this to do with cats on the internet? Well, unlike Neanderthals, modern humans devoted their brains to social networking – being able to store and recall details of a wider social circle. This allowed humans to forge long-range alliances, both for trade and for intermarriage, and so exploit a much wider range of resources than Neanderthals could comprehend.

Neanderthals would never have understood the internet, nor the ability we humans have to communicate with people, many of whom we've never met, over long distances.

Henry Gee is a palaeontologist and evolutionary biologist, and a senior editor of the journal *Nature*





## INSIDE SCIENCE

# ROBERT MATTHEWS

**W**HEN A HUGE multinational company claims to be doing its bit to make the world a better place, it's hard not to be cynical.

So when Coca-Cola launched its latest international PR campaign claiming to be keen to stop us all becoming lard-arses, it probably expected to get a kicking.

And sure enough, there was little praise for the world's leading purveyor of sugary, coloured water. The ads stressed Coca-Cola's record of reducing calories in its drinks, pointing out it started selling zero-calorie versions of its beverages decades ago, and that over half of the drinks it sells in Europe are now low or zero calories.

As a big fan of Coke, I knew that – and have cheerfully guzzled supertankers' worth of the diet variety for decades. But these ads leave a bad taste in my mouth. According to the nice lady doing the voice-over for the TV ads: "The simple, common sense fact is that all calories count."

It seems like common sense. After all, everyone knows a calorie is a calorie – whether it comes from a bottle of sugary Coke or an organically farmed, knit-your-own orange. As for the cause of obesity, that's surely common sense too. "If you eat and drink more calories than you burn off, you'll gain weight," says the same lady. "That goes for Coca-Cola and everything else with calories."

Again, you can't argue with that. It's simple physics – conservation of energy. If your body doesn't use the energy, it'll turn it into energy-storing fat instead. Many nutritionists wouldn't argue with it either, because they view it as some kind of fundamental law of nutrition. Indeed, when this idea was first put forward in the 1880s, it was given a fancy physics-sounding name: the 'isodynamic law', according to which all calories are the same as far as the body is concerned, regardless of whether they're carbs, protein or fat.

But these nutritionists are fooling themselves – and us. In reality, living organisms are more complex than anything physicists deal with. Sure, the law of conservation of energy applies to humans just as it does to black holes and quarks, but not in the way we're led to believe. When it comes to nutrition, the idea that there's a simple law controlling the energy you put in your mouth, how much you use and how much ends up hanging over your trouser belt is laughable.

**"Next time you sit down to eat, take a look at your food. It may look familiar, but chemically it's incredibly complex"**



Next time you sit down to eat, take a look at your food. It may look familiar, but chemically it's incredibly complex, and so is your body's response to it. We burn up twice as much energy to metabolise proteins as to process carbs, while insoluble fibre – which also contains calories – just passes through us. Nutritionists have some rules of thumb that try to factor in these differences, but they can't cope when faced with the complexities of a plate of meat, two veg and a cold beer. Then there's the mind-boggling complexity of what the body does with any excess energy left over from your dinner. The fibre may pass right through, but the carbohydrates trigger the release of insulin, which persuades cells to store excess energy as fat. And the worst carb for doing this is the one you'll find in almost half of Coca-Cola's drinks: sugar.

To be fair, it's not just Coca-Cola. A recent survey showed that 80 per cent of food sold has extra sugar added to it. Manufacturers have over 50 fancy names for it, from corn syrup to fruit-juice concentrate, but it's all linked to ill-health. So why do companies do it? Well, it tastes good, but there's also evidence that sugar triggers an addictive reaction, which makes us crave more.

Coca-Cola insists that it's committed to providing consumers with "fact-based nutrition information". I'd be more convinced if it cut out the sugar – and the tosh about a calorie being a calorie. ■

**ROBERT MATTHEWS is Visiting Reader in Science at Aston University, Birmingham**

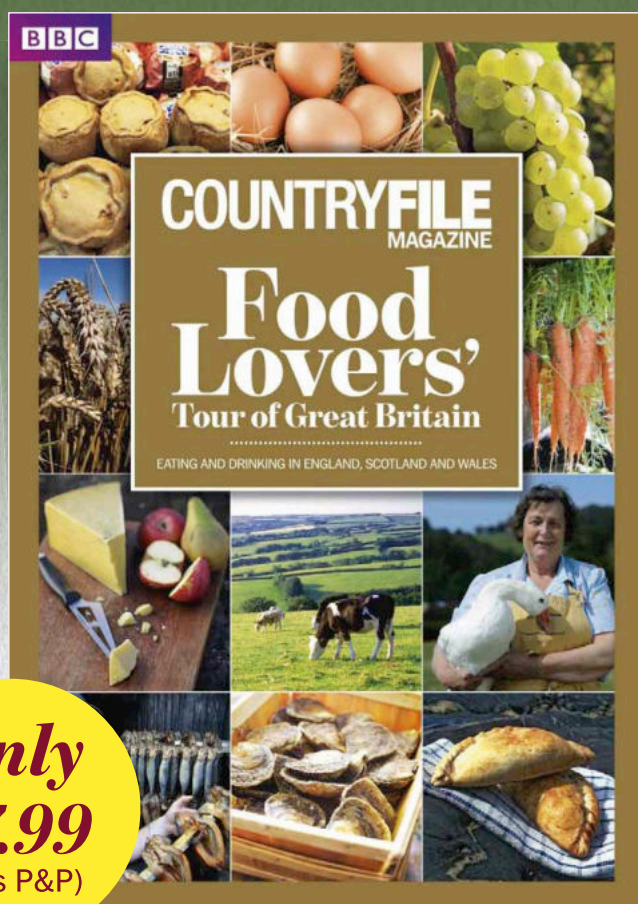


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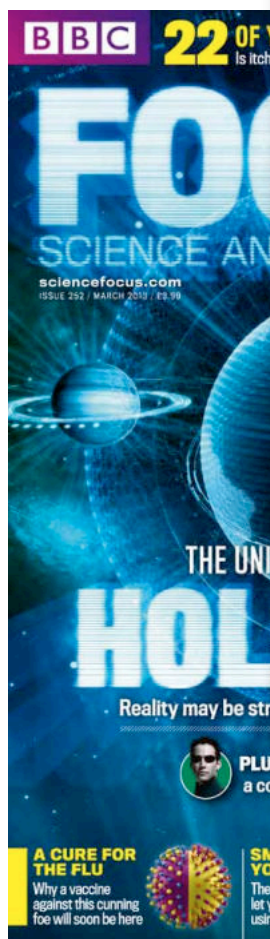


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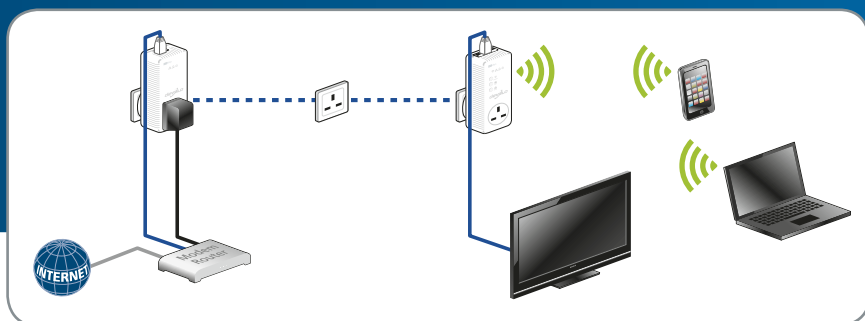
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## HIDDEN TREASURES

# HELEN CZERSKI

**P**atter patter. Crackle... clink. Patter. Tap, tap, tink. Patter. Silence.

My sister wandered in the next morning and asked how I'd slept. "I think you've got a mouse," I said. I could tell her the route the furry little adventurer had taken: across the floor, past a plastic bag, a quick nose around the base of the metal bin and off to investigate Mouse Shangri-La (the food cupboard, as the rest of us know it). And I could do all that even though it had been pitch black and I had never left my bed. Why is that? How can we get so much information from sound?

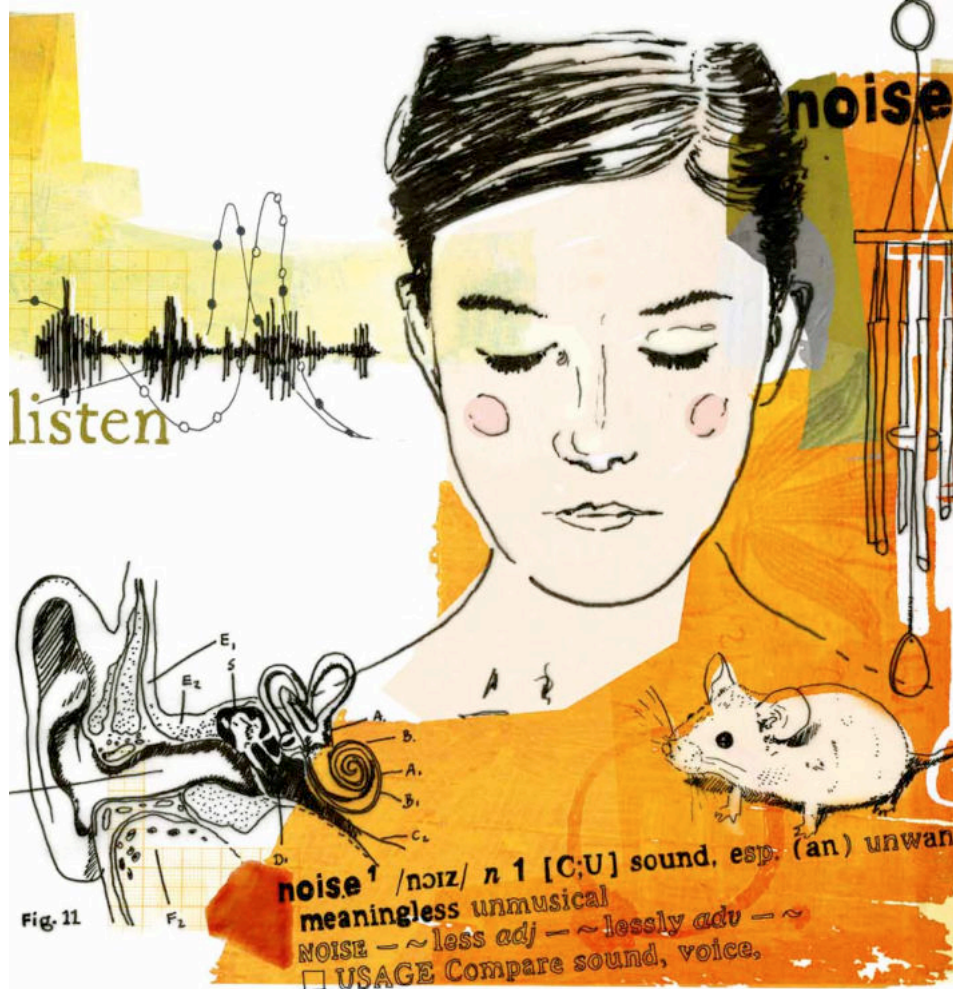
We live in air, and it's vibrating. When a hammer strikes a bell, the whole bell wobbles and pushes on the air next to it. That air pushes on the next bit along, and the ripple spreads out into the atmosphere. Close your eyes for a second and listen. The air all around you, right now, is pulsating. Your ears are pressure sensors, and you are detecting pale imitations of what the air was doing next to objects somewhere else. Listening tells you a lot about what the object itself was up to. And that's useful because the way something vibrates depends on what it's made of and what shape it is.

If you have a mug to hand, tap on it with a spoon. The mug has to change shape as you tap it (you're squashing it ever so slightly), and then it pulls itself back into shape and overshoots, pulls itself back and overshoots again, and this vibration continues. The mug is ringing at what's known as its 'natural frequency'. If the mug is bigger, or made of heavier material, it will take longer to go through one cycle. And so we know that bigger or heavier objects ring with deeper notes: a lower frequency. The specific shape of each object gives it many possible patterns of vibration, and the sound produced is lots of those patterns added together. A ceramic mug rings for longer than a plastic one, because the plastic absorbs the vibration energy more quickly.

That's why plastic gives you a dull 'thunk' instead of a clear 'ting'. Whenever you hear a sound, you are hearing physical structure.

Try tapping a mug around its rim and you'll hear a change in pitch depending on where you tap. Tapping directly opposite the handle produces a lower note than if you tap it at 45° to the handle. That's due to the pattern of the main vibration. If you tap at 45° to the handle, the handle is in a spot that doesn't move at all. The mug effectively has less mass – it's lighter – so it vibrates more quickly and produces a higher note.

**"When you consider that we don't even have to be facing the source, the level of detail we get from sound is astonishing"**



These are the principles behind musical instrument design – specific physical structures are chosen to make sounds we like. But I like to think of the whole world being an orchestra – the orchestra of everything. The instruments are silent until bumped or moved, and then their structural secrets are given away as they vibrate. We are actually experts at interpreting sound, but we're rarely conscious of doing it.

When you consider that we don't even have to be facing the source, the level of detail we get from sound is astonishing. Moving a wooden chair? Putting down a metal bucket? The differences are obvious. And our ears are really sensitive, so the knock needed to start a

detectable vibration can be very slight. My sister's rodent percussionist could easily start a whole bin oscillating. Even a mouse can play the orchestra of the world. ■

**DR HELEN CZERSKI** is a physicist, oceanographer and BBC science presenter whose shows include *Operation Iceberg* and *Orbit*

THIS DUST CLOUD  
IS ABOUT TO BE  
SWALLOWED BY  
THE BLACK HOLE  
AT THE CENTRE  
OF OUR GALAXY.  
WHAT WILL  
HAPPEN NEXT?

by Paul Sutherland





A giant gas cloud will go  
down a cosmic plug hole  
this year, as shown in  
this artist's impression



A

NY TIME SOON, a wayward stream of gas and dust will be dragged inside the black hole that lurks at the heart of our Galaxy, the Milky Way. No-one has witnessed such an encounter in detail before, so no-one knows exactly what will happen.

This is why it's such a fascinating prospect for astronomers.

The most enigmatic objects in the Universe, black holes are formed when a star collapses. Inside them space and time as we understand them cease to exist. Gravity is so strong within them that nothing escapes their clutches – not even light. That means they can't be observed directly by astronomers; they reveal their ominous presence from the way their gravity affects the movement of nearby stars.

We may never completely understand what goes on inside black holes – venturing inside would be a one-way trip. But we can hope to get a better handle on what goes on around them. Black holes become more massive by munching on matter – sometimes whole stars, but mainly clouds of gas and dust. And the collision between the gas cloud and the black hole at the centre of our Galaxy, Sagittarius A\*, is an ideal opportunity to watch one of these feeding frenzies as it happens.

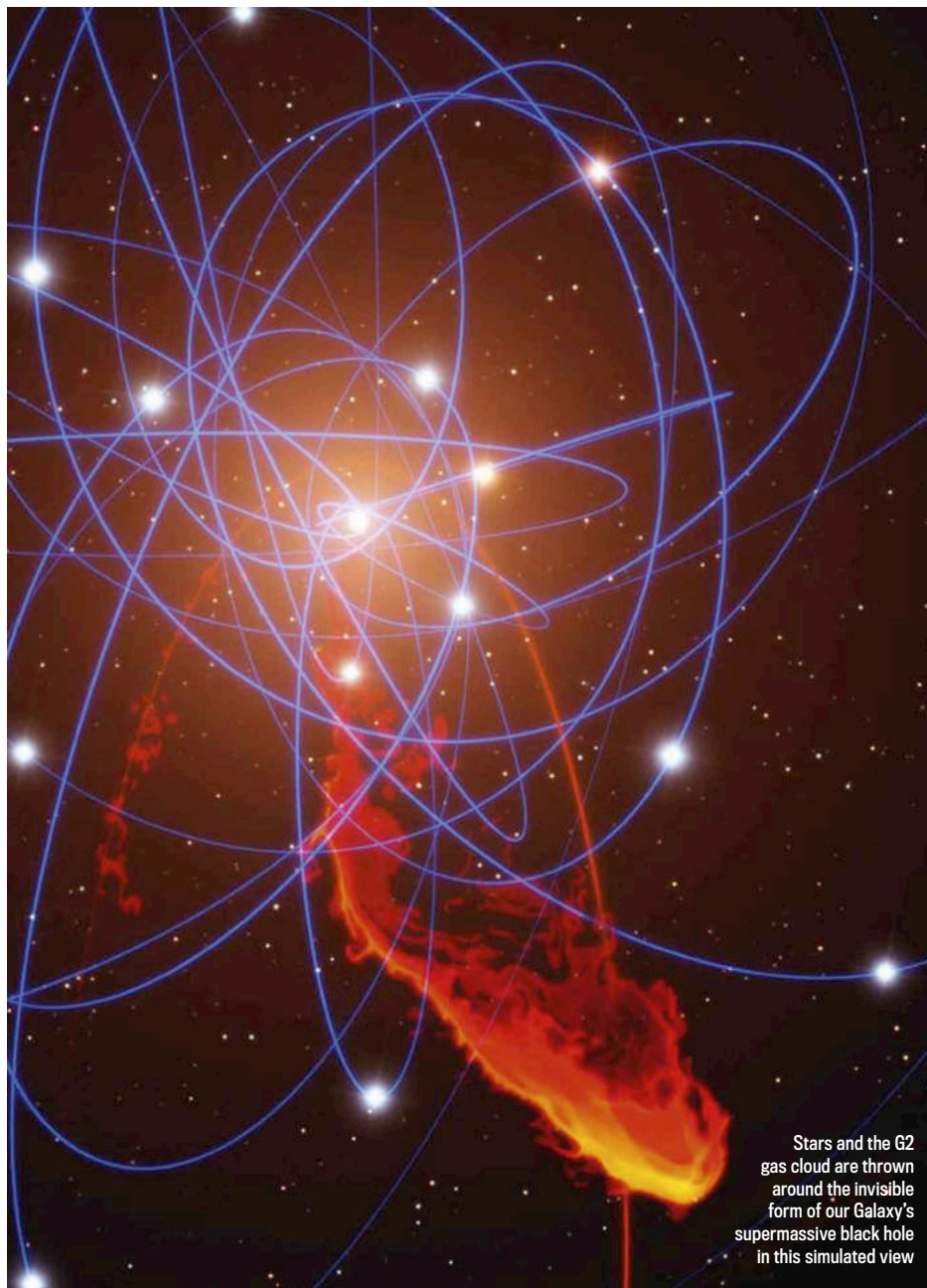
At only 26,000 light-years, or 254 trillion kilometres, from Earth – a short distance in astronomical terms – Sagittarius A\* is the only supermassive black hole close enough to observe in detail. It means astronomers have a ring-side seat for the impending collision.

## A CHANCE FIND

It's an incredible opportunity, but astronomers could quite easily have missed it. The gas cloud, named – rather unimaginatively – G2, was only spotted in 2011 and there was a good measure of luck involved in its discovery.

“As is typical in science, it was a bit of a random find,” says Dr Stefan Gillessen, of the Max Planck Institute for Extraterrestrial Physics in Germany, who led the team that spotted the cloud. His researchers were examining images taken nine years earlier using Europe's Very Large Telescope in Chile, looking at the visible glow around Sagittarius A\*. The glow is generated by friction in the gas and dust that orbits the black hole in the ‘accretion disc’.

“We decided to compare our data over the years and it struck us that there was something rather faint but visible moving towards the position of the black hole,” says Gillessen. “It had been sitting there quietly in the data since 2002. Then we found we had recorded spectroscopic data that showed



Stars and the G2 gas cloud are thrown around the invisible form of our Galaxy's supermassive black hole in this simulated view

## “There was something rather faint but visible moving towards the black hole”

Dr Stefan Gillessen, of the Max Planck Institute for Extraterrestrial Physics in Germany

the object was larger in 2011 than it was in 2004. It had stretched along an elliptical orbit around the black hole.”

This stretching shows the gas cloud is already feeling the effects of the black hole's substantial gravity. What will happen next, though, is the million-dollar question. At four million times the mass of the Sun, Sagittarius A\* is a monster – a ‘supermassive’ black hole. In fact, matter-munching phenomena like this lie at the centres of many galaxies. So-called active galaxies – those emitting lots of light – have them with sizes billions of times the mass of the Sun.

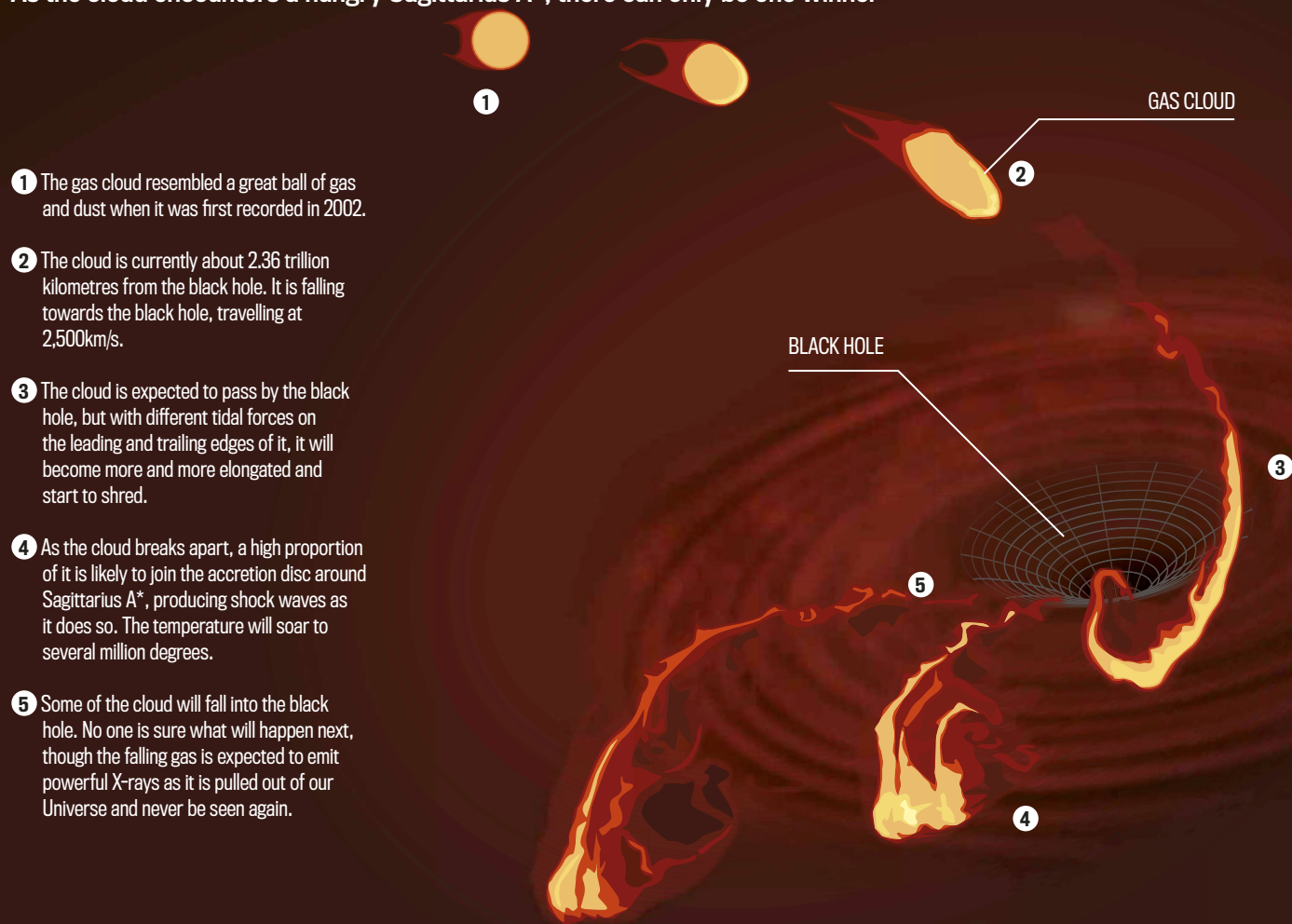
Sagittarius A\* came into existence billions of years ago, perhaps when some very massive stars collapsed at the end of





# GAS CLOUD VS SUPERMASSIVE BLACK HOLE

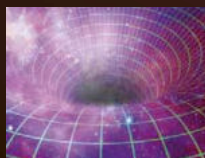
As the cloud encounters a hungry Sagittarius A\*, there can only be one winner



- 1 The gas cloud resembled a great ball of gas and dust when it was first recorded in 2002.
- 2 The cloud is currently about 2.36 trillion kilometres from the black hole. It is falling towards the black hole, travelling at 2,500km/s.
- 3 The cloud is expected to pass by the black hole, but with different tidal forces on the leading and trailing edges of it, it will become more and more elongated and start to shred.
- 4 As the cloud breaks apart, a high proportion of it is likely to join the accretion disc around Sagittarius A\*, producing shock waves as it does so. The temperature will soar to several million degrees.
- 5 Some of the cloud will fall into the black hole. No one is sure what will happen next, though the falling gas is expected to emit powerful X-rays as it is pulled out of our Universe and never be seen again.

## BLACK HOLES THROUGH TIME

The evolution in our understanding of these strange phenomena



**1783** Leading British scientist John Michell, a clergyman, suggests that some stars might be so dense that light cannot escape their gravitational pull. Is this in essence what a black hole is? Yes.



**1915** Albert Einstein shows that gravity is a warp in space-time caused by matter. This tells astronomers that black holes can exist if gravity is sufficiently strong. It showed that something can collapse so much that nothing, not even light, can escape.



**1963** Astronomer Maarten Schmidt discovers that a distant object called a quasar is a galaxy powered by a supermassive black hole at its centre.



**1967** Physicist John Wheeler coins the term 'black hole', saying it shows that "space can be crumpled like a piece of paper into an infinitesimal dot".



**1974** British physicist Stephen Hawking declares that a black hole can emit a form of radiation that will cause it eventually to evaporate.



**2013** Gas cloud G2 gets too close to the supermassive black hole at the centre of our galaxy, Sagittarius A\*, the resulting encounter providing an unprecedented insight into the feeding habits of black holes.

→ their lives, coalescing into one massive object. The gas cloud is also something of an unknown quantity – its composition is still a mystery. But the gas part will mostly be hydrogen and astronomers know the whole cloud is a searing 10,000°C as it moves through space – almost twice as hot as the surface of the Sun.

Astrophysicist Stephen D Murray, of the Lawrence Livermore National Laboratory in California, thinks the cloud could be the result of some kind of stellar burp, in which a star lost part of its outer atmosphere. But that's far from clear. "One of the best guesses may be that the cloud was ejected from a star," says Murray. "Otherwise it is difficult to know how something that small with little gravity could have held itself together. It seems an amazing coincidence for a star to eject something like this so close to a black hole, so it is a really wonderful way of tracing out what happens to an object in that vicinity."

Murray is part of a team that has had a go at predicting how the close encounter between the gas cloud and Sagittarius A\* will play out. They have modelled the encounter in 3D using the computational brawn of the Palmetto supercomputer at Clemson University in Anderson, South

## "Something that started out looking like a ball is going to be stretched into a bit of a noodle"

Astrophysicist Stephen D Murray, of the Lawrence Livermore National Laboratory in California

Carolina. The team's simulations, which required more than 50,000 computing hours on 3,000 processors, show that the cloud's closest approach to the black hole is likely to be some time this summer, or early autumn.

The first signs of the encounter will be heat released by the gas cloud as it sheds energy on getting closer to Sagittarius A\*, falling increasingly under the influence of its gravity. This energy release will be detectable by radio and X-ray telescopes on Earth as well as orbiting satellites (see 'Eyes on the encounter', on p41).

But this will not be a head-on collision. The cloud will initially slip past Sagittarius A\* at quite a distance from it – it will be about 200 times as far as Earth is from the Sun. But that won't stop the black hole's gravity wreaking havoc. "Basically the gas cloud is just going to get shredded," says Murray.

"Our models show the cloud will get stretched due to the difference in the black hole's gravitational pull on one end and the other. It means that something that started out looking like a ball is going to be stretched into a bit of a noodle."

"There will be other effects too," Murray adds. "As it moves through all the gas at the centre of the Galaxy, the cloud is going to start rippling like waves on the surface of an ocean on a windy day. And there are other various instabilities that will come into play. So it will be both stretched into a noodle shape and ripped apart. By the time it is done it will have orbited beyond the black hole and it will probably no longer be a coherent structure."

As the cloud breaks up, much of it will join the accretion disk around Sagittarius A\*, or just fall into the black hole itself. "It would be much more spectacular if the whole thing was falling in," says Murray. "Our model isn't predicting that huge a difference in the black hole's output. But there'll be a few small firecrackers."

## THE LEARNING CURVE

While it's unlikely to be the most spectacular of celestial events, it will still be fascinating. "Watching what happens to this gas cloud will help tell us how atmospheres [accretion discs] around black holes are structured," says Gillessen. "From the amount of friction the cloud experiences, we can estimate how much gas there is and so learn how such an atmosphere is made. It will also be useful to see how the gas circles the black hole to help tell us how it is being fed. Nobody has ever seen that."

As for the fate of the material that falls into Sagittarius A\*, Gillessen will not even speculate. "That's not a scientific question because we have no way of ever knowing," he says. "You cannot even

## THE ULTIMATE BLACK HOLE TELESCOPE

Earth-sized 'scope could bring Sagittarius A\* closer than ever before

IT IS IMPOSSIBLE to see inside a black hole. But astronomers are aiming to do the next best thing by building a telescope that can zoom in to look at the immediate surroundings of one like never before.

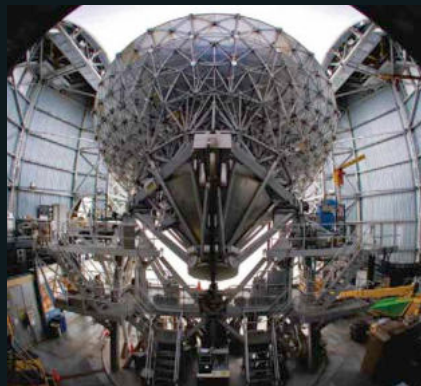
Their goal is to create an instrument powerful enough to view what is going on at the event horizon – the point beyond which nothing, be it stars, a gas cloud, or even light, can escape. It would have a higher resolution than any of the telescopes that will observe the impending collision between a gas cloud and the black hole Sagittarius A\*.

The Event Horizon Telescope (EHT) will not be a new standalone observatory perched on some remote mountain. Instead, the consortium planning it intends to combine the observing abilities of existing radio telescopes around the world, allowing them to collectively work with the resolving power of a single observatory the size of our planet. That power will allow astronomers to view details such as the ring of light escaping from matter that has managed to avoid being dragged inside the black hole.

Twenty observatories around the world have signed up to be part of this telescope

array that could be up and running as soon as 2015. As well as Sagittarius A\*, another target will be a giant elliptical galaxy called M87 lying 53 million light-years away. It is home to a central black hole that is much more massive, with six billion times the mass of the Sun.

For more on the Event Horizon Telescope see the January 2013 issue of Focus. call 0844 844 0260 to order a back issue.



The James Clerk Maxwell Telescope on Mauna Kea, Hawaii will form part of the Event Horizon Telescope





The monstrous black hole Sagittarius A\* sits in the bright centre of this image taken by the Chandra X-Ray Observatory

imagine an experiment that might verify or challenge any claim. The only way to check would be to jump into the black hole – but just make sure you say goodbye to everyone first!”

Theory has it that a black hole is largely empty, with its mass confined in an incredibly small point at its centre, the singularity. An alternative theory posits that anything falling into a black hole – such as a doomed gas cloud – falls into another universe inside. Mind-bending stuff.

## “The cloud will get stretched due to the difference in the black hole’s gravitational pull”

Astrophysicist Stephen D Murray, of the Lawrence Livermore National Laboratory in California

So the gas cloud’s ultimate fate will remain the stuff of speculation. But there will still be plenty to watch on the outside of the black hole. Although the action will start over the next few months, its effects are likely to be seen for the next few years – the gas cloud will be the dominant fuel for Sagittarius A\* for some time. So the coming years will be an interesting time for black hole astronomers who will be able to watch events unfold up close. Thankfully, up close means something different to astronomers than it does the rest of us – there’s no chance that we’ll become Sagittarius A\*’s dessert. ■

Paul Sutherland is a space and astronomy writer and the author of *Where Did Pluto Go?*

### Find out more

<http://bit.ly/YVrW4c>

Simulation of the gas cloud’s fate

**BBC Universe – Black Holes**

<http://bbc.in/14Te8zq>

## EYES ON THE ENCOUNTER

Earth and space-based ‘scopes will be watching the collision



**ALMA:** The world’s highest observatory, 5,000m up in Chile’s dry Atacama Desert, has begun monitoring the collision using its array of 66 dishes. These scan the skies for radio wavelengths.



**Chandra:** NASA’s Chandra space telescope is one of several satellites that will observe X-ray emissions to see how much Sagittarius A\* brightens as the gas cloud collides with its event horizon.



**VLT:** The European Southern Observatory’s Very Large Telescope in Chile will follow the changing shape of the G2 gas cloud and see how its brightness changes at optical wavelengths.



**Integral:** Europe’s Integral satellite watches for high-energy gamma-rays and will check for any outbursts from the black hole at this extreme end of the extended spectrum of light.



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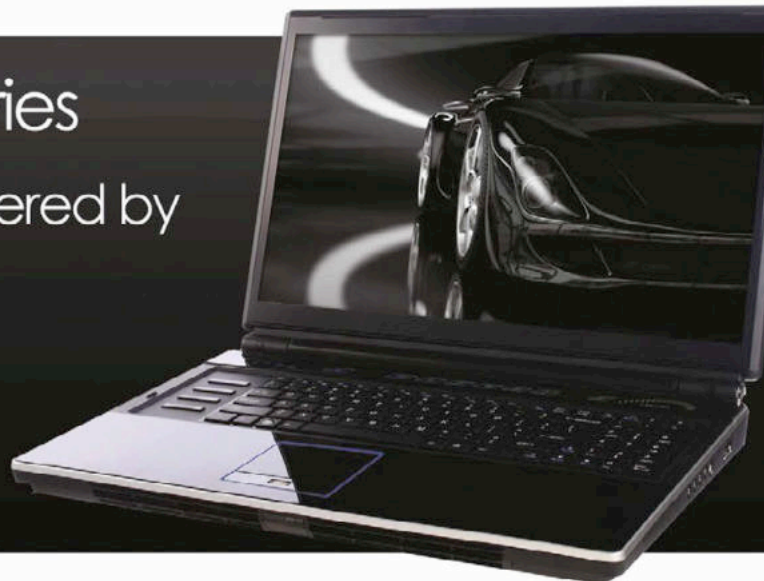




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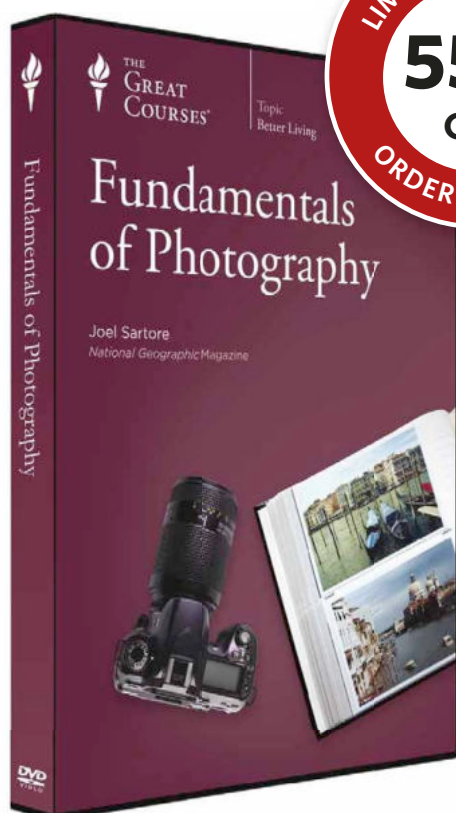
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# FAKE IT ON FACEBOOK

Transform yourself from a lonely online caterpillar into a social butterfly today, with **Jeremy Dean's** six simple steps

Illustration: Robin Boyden

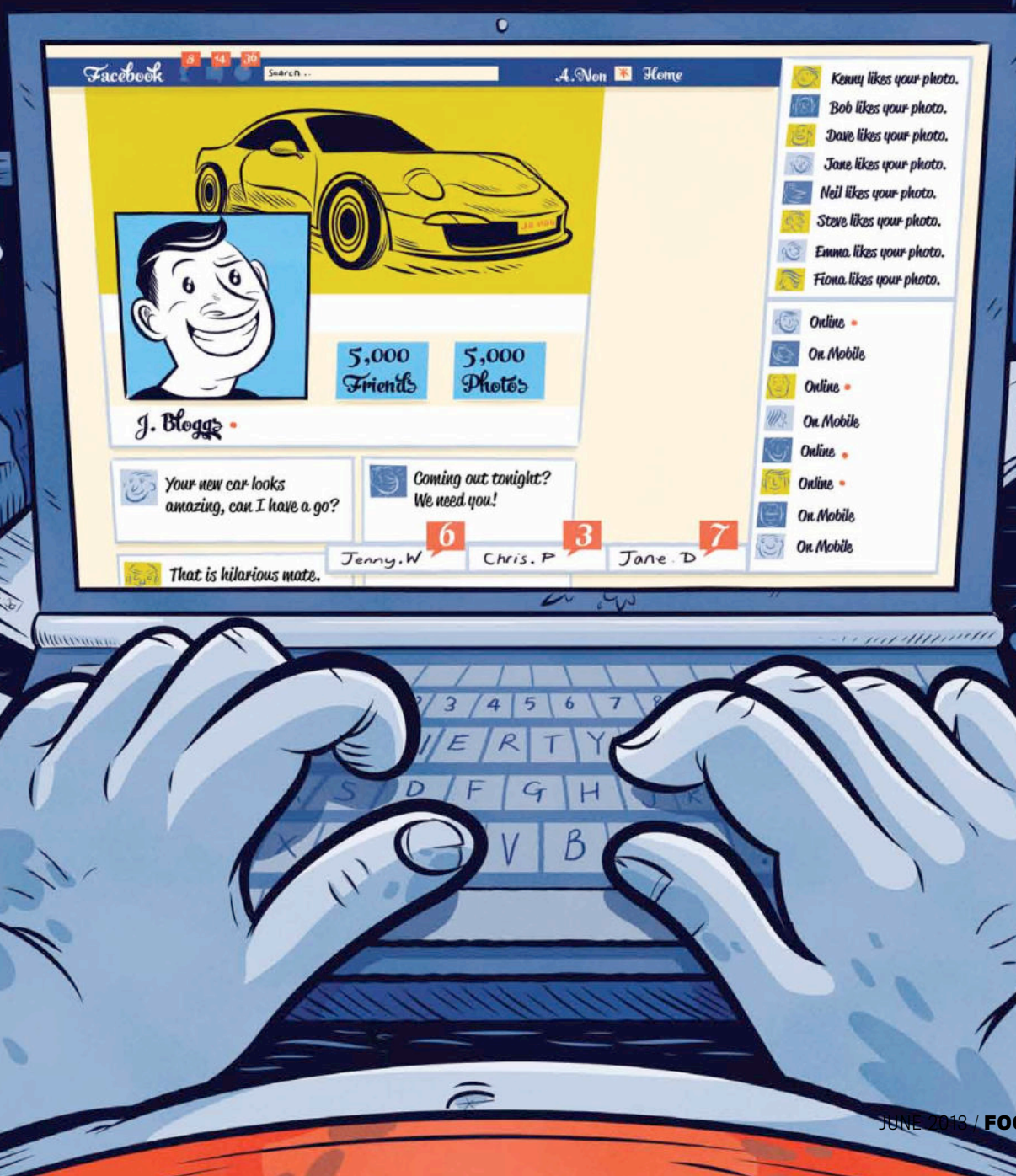
**P**EOPLE CAN BE less than honest when it comes to what they say about themselves online. We've all seen our share of 'professional lion tamers' and 'part-time racing drivers' on the likes of Facebook and Twitter. But is it possible to lie and get

away with it? Are there ways to tweak your profile and online behaviour to appear more attractive, win more friends and gain more social clout?

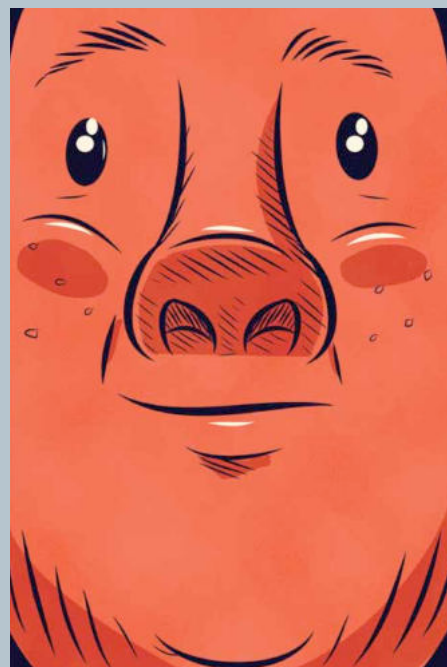
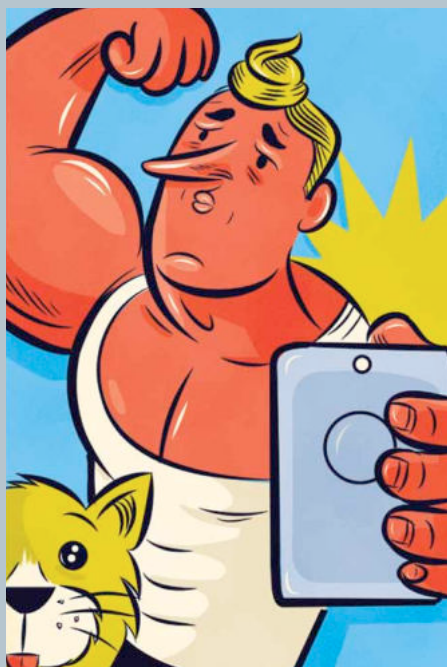
The answer is yes. New research from the University of Helsinki has shown that even the smallest of tweaks to your

Facebook profile can convince onlookers that you are more confident, open-minded and attractive than you really are.

So, how best to conquer the online world and present yourself in the best possible light to others? Here are six steps to set you on the right course. ➔







## MAKE A NEW PROFILE PHOTO

FIRST IMPRESSIONS ARE important. In fact dozens of studies have shown how initial meetings create stubborn imprints that are difficult to scrub out. The digital equivalent of a first impression is your profile picture, and people can apparently tell a surprising amount just from this.

One study by Finnish psychologists asked 50 participants to pose for 11 photographs, expressing a variety of personality traits, such as enthusiastic or carefree. The photos were then shown to 401 people who were asked to rate the fake

personalities being portrayed. It proved that different aspects of personality can be quite easily conveyed by different poses.

In other words, your profile picture can make you look more or less neurotic, extraverted, agreeable and so on. For example, people in the study that looked away from the camera, rather than directly at it, were perceived as more open-minded. So show your profile picture to someone else and ask them what aspects of your personality it seems to be portraying. You might be surprised, or possibly

appalled. Either way it's useful to get someone else's perspective.

Pictures don't just convey personality, though. Viewers also make social inferences from them. Researchers at the University of Missouri have found that profile pictures which included social cues were seen by others as being more socially and physically attractive. Social cues might include you holding a guitar or playing tennis: something that demonstrates who you are. The regular head-and-shoulders shot may not be playing to your strengths.





## PICK YOUR FRIENDS CAREFULLY

SHALLOW AS IT might seem, real-world studies of attraction generally find that individuals are perceived as less attractive when they're surrounded by objectively beautiful people – the comparison doesn't do anyone any favours. But in the online world the opposite is true. It's the old proverb that a person is known by the company they keep.

One study led by Joseph B Walther looked at the effect of the physical attractiveness of who you're connected to on social networks. What they found was that a person's physical attractiveness was boosted by having more physically attractive friends on their page. That doesn't necessarily mean you should shun your less aesthetically pleasing friends. Nevertheless, be aware that they're not making you look better in comparison, but worse by association.

It's not just who you add as a friend, either. What they say is important too. According to a study from the University of Missouri, people online are very responsive to the types of comments that others make on your photo and your profile in general. These should validate your online self-presentation or readers may smell a rat. Even jokey, negative comments make you less appealing, according to this study. It's better to get rid of any silly or sarcastic comments posted by friends.

**“A person's physical attractiveness was boosted by having more physically attractive friends on their page”**

## DON'T SEEM SHALLOW

THE TEMPTATION IS to see social networking as a kind of competition to see who can attract the most followers or friends. But does having thousands of Facebook friends appear realistic or attractive? That is the question asked in research led by Stephanie Tom Tong from Michigan State University. They mocked-up five almost identical Facebook profiles, which they showed to participants, asking them how attractive the profiles were. The only difference was the number of friends displayed, which ranged from

102 to 902. It turned out that the profile with 302 friends was considered the most socially attractive to others.

Over-inflated friend-counts, though, are just one way in which we might exaggerate who we really know and what we're really like. Isn't this what everyone is apparently doing online? Pretending to be someone they're not?

Research that questions this view comes from an analysis of 236 German students whose social

networking profiles were compared with their personality scores. Both their actual and idealised personalities were tested; in other words, both who they were and who they wanted to be. Comparisons with their social networking profiles showed that they were, in fact, more likely to be displaying their real selves and not their idealised selves.

The moral of the story is that even though you could be anyone online, most people display their real selves – and that's what they'll expect from others.

# KEEP (SOME OF) YOUR INHIBITIONS

WHILE GIVING UP your personal information to others has been shown to help foster social connections, there are, of course, limits. You need to be wary of something called the 'online disinhibition effect'. This is the fact that many people loosen up a little too much online: they will say, or admit, things while online that they would never say to someone's face. The reason is that online we feel more invisible and anonymous than we do in everyday life, even on social networking sites. It's the reason people post pictures of themselves blind drunk or list their home phone numbers.

Recent research by the University of Western Ontario has looked at what a sample of 400 Facebook users actually disclose. It emerged that 88 per cent revealed their birthdays, 63 per cent their relationships status and 55 per cent their sexual orientation. Less commonly disclosed were their jobs (33 per cent), mobile phone number (5 per cent), and home address (4 per cent). Those most likely to disclose more information about themselves were younger people and those who were single.

The figures reveal that the online disinhibition effect is very real. And disclosing too much information can be just as much of a problem when it comes to identity theft as it is for your work or social life. So, while it's probably no bad thing to display your true personality and tell people about who you are and what you're interested in, be aware that the internet is not as anonymous as it feels. First impressions are near indelible, so it's worth remembering that those pictures of you at 3am on St Patrick's Day might not be showing your best side.



## FILL YOUR PROFILE

ONE OF THE barriers to trusting people online is knowing who they are. This is especially important on social networking sites where people are more likely to follow people that they know and trust. That's why boosting trust with social proof is really important. An easy way to boost trust on Facebook is by completing your profile. A study by Michigan State University that looked at user profiles on Facebook found that populating more of these fields, like home town, gender, favourite films and so on, attracted more friends.

But why should completing your profile promote trust? After all, you could write whatever you like. The reason is that if you lie on your social networking

profile about, for example, being a 'King of Kayaking', you'll be called on it by people who know you can't swim. The assumption, then, is that friends and family will keep you honest so that strangers can trust your profile as well.

Just the same effect has been shown in another study on Twitter. Those who completed their user profile, including things like location and web address, as well as providing a longer description, generally attracted more followers. Other users tend to respond positively to these little self-disclosures, just like in an offline conversation when you share something personal with another person, it brings you slightly closer together. ■

### Find out more

**4** Aleks Krotoski looks at how social networks have affected society in *Digital Human* <http://tinyurl.com/ceuabur>

Jeremy Dean is the founder of **PsyBlog** ([psychblog.co.uk](http://psychblog.co.uk)) and the author of *Making Habits, Breaking Habits*



# INFORM, DON'T 'MEFORM'

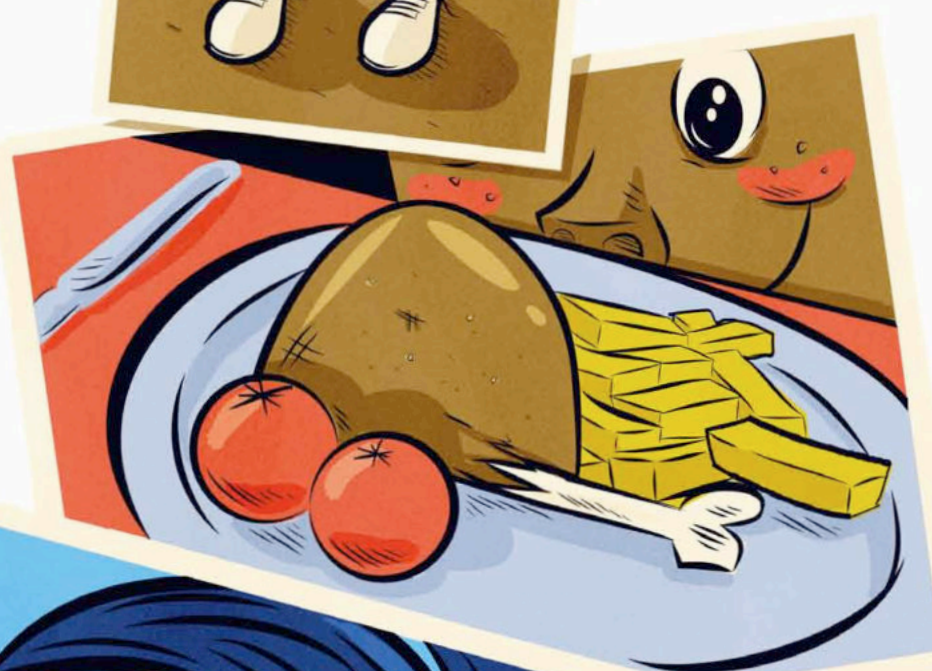
WITH SOCIAL MEDIA the temptation is to go on about yourself. The mechanism of loads of little updates seems perfect for relating the minutiae of everyday life: this is my toast; here's me eating the toast; this is what I think about the dangers of hydraulic fracturing.

There's nothing wrong with expressing your own opinions as some of your followers may be interested. Indeed a Rutgers University study on a sample of 350 messages collected from Twitter found that 80 per cent of Tweeters fell into this category, which they dubbed 'meformers'.

The problem with being a 'meformer' is there's only a limited audience who are interested in hearing about you and your activities, and you won't stand out. For more success on social networks, you've got to fill at least some of your tweets or updates with some juicy information.

The power of *informing* versus *meforming* was nicely demonstrated in a recent study led by a Georgia Tech researcher who gathered half-a-million tweets over 15 months to see what factors are associated with increased follower-count. They found that *informers* pulled in 30 times as many followers as *meformers*.

So if you want to build a follower base then you've got to find your informational niche and demonstrate that you'll feed followers with fascinating on-topic stuff.



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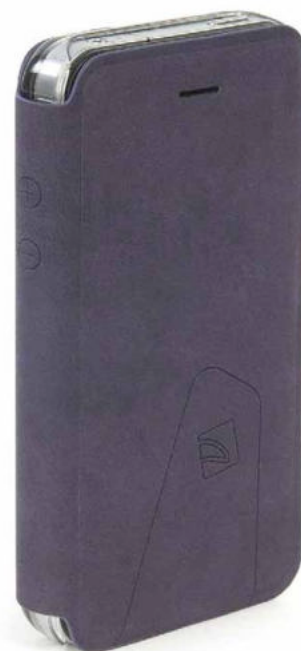
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# THE FUTURE



The food factories of the future might not be serving up a burger in the traditional sense...



# OF FOOD

Why crickets, GM tomatoes and lab-grown meat could soon be turning up on a dinner plate near you

Words: Hannah Devlin and Nic Fleming Illustration: Coneyl Jay



**D**EMAND FOR FOOD is set to double in the next 40 years, according to World Health Organisation figures. Yet we're fast running out of space in which to grow it. A booming population and rising prosperity are fuelling the spiralling demand, and the situation is particularly dire when it comes to meat.

Our appetite for animal flesh is set to double by 2050, and with close to 70 per cent of the world's farmland already devoted to raising livestock, the prices of conventional meats are

widely expected to spiral. Henning Steinfeld of the UN's Food and Agriculture Organisation (FAO) has gone as far as saying that beef will become "the caviar of the future".

The environmental costs of today's burgers and steaks are considerable too. Keeping livestock for food produces 39 per cent of all emitted methane and five per cent of carbon dioxide. "It is just not sustainable from an ecological point of view," says Professor Mark Post, a physiologist at Maastricht University. "We have to come up with alternatives."

Post is among a band of researchers around the world working to avert the looming food

crisis using science. His research could lead to a future in which our meat is grown in labs rather than on farms.

Other solutions are just as radical. As seen in the recent BBC Four programme *Can Eating Insects Save The World?* with Stefan Gates, many experts predict insects will start creeping into Western diets. What's more, ingenious techniques are being developed that would allow our fruit and veg to be grown in deserts.

Here *Focus* has brought together leading solutions to the impending food crisis. Take a look to see which of them you find the most palatable.





# INSECTS



Six-legged food is marching towards your dinner plate

➔ WITH DEMAND FOR meat escalating, how are carnivores of the future going to get their fix? How about some grasshopper tacos, caramelised locusts or mealworm minestrone? Some scientists believe entomophagy, the consumption of insects, will play a significant role in providing alternative sources of protein.

"When it comes to the conversion of feeds into meat for humans, insects are many times more efficient than traditional sources," says Professor Arnold van Huis, an entomologist at Wageningen University in the Netherlands. "This is because they are cold-blooded and so don't have to expend energy maintaining their body temperature." Crickets, for instance, produce a kilogram of edible material from just 2.1kg of feed. For poultry, the figure is 4.5kg. It's 9.1kg for pork and 25kg for beef.

Then there are the environmental benefits. Livestock accounts for 18 per cent of man-made greenhouse gases: for every kilogram of beef farmed around 2,850g of greenhouse gases are released. For mealworms and house crickets, the figures are 8g and 2g respectively, according to a 2010 study led by van Huis.

A diet of bugs seems like a no-brainer, so a research group at Wageningen University is investigating what is likely to be the biggest stumbling block to getting them on plates – public perception. It is carrying out tasting sessions to see how willing consumers are to eat insects and whether presenting them whole, grinding them up or extracting the protein is the best approach. "We found nine out of 10 people preferred insect meatballs to conventional ones," says van Huis. "Disguising the protein in this way is the angle we'll need to take."

Even those in the industry realise it's going to take a lot to change our aversion to six-legged foodstuffs. "In the West we are going to need to overcome historical psychological issues," says Ernest Papadoyanias, president of Organic Nutrition Industries. "I think it'll go viral through high-profile chefs picking it up." His Florida-based company is about to produce



Mealworm quiches are prepared at the Rijn IJssel school for chefs at Wageningen as part of an insect cookbook developed with the university

## "We found nine out of 10 consumers preferred insect meatballs to conventional ones"

1,000 tonnes of dried, ground black soldier flies per year for aquaculture feed. Realistically, it's as a foodstuff for animals we are keen on eating that insects are likely to rise to prominence. From June, insects will be allowed in aquaculture feeds in the EU.

As well as issues of perception, there are likely to be other complications. For instance, some of the proteins contained in edible insect species are the same as those in house dust mites, which can cause asthma.

However, if Papadoyanias is right that celebrity chefs are the key to Western diners' hearts, we may not have long to wait for the insect food revolution to start. Van Huis claims representatives of a well-known British celebrity chef have recently been in touch about a Dutch insect cookbook he co-authored. It's due out in English in September.

## TOP 5 INSECTS CURRENTLY CONSUMED AROUND THE WORLD



### GRASSHOPPERS

Eaten in China, the Middle East and many African countries. Toasted with garlic and lime juice in Mexico, and candied in Japan.



### CATERpillars

Widely eaten in central and southern Africa – given to children in a paste to counter malnutrition.



### GIANT WATER BUGS

Popular in Thailand, they are boiled, steamed, deep-fried, added to salads and chilli pastes. They are said variously to taste of bubble gum, jelly beans or scallops.



### WEAVER ANTS

Highly prized as a delicacy in parts of southeast Asia, they are fried with shallots, chillies, lime and spices and served with sticky rice. Sometimes crushed to make salsa.



### SILK WORMS

Crunchy on the outside and gooey within, they are eaten whole and fried with kaffir lime leaves in Thailand. The pupae are popular as street snacks in Korea.

## NUTRIENT COMPARISON

All figures are for a 115g serving, roughly the weight of a quarter-pounder burger

**Caution:** nutritional values can vary depending on factors including specific species, sex, cooking method, feed, age when killed and environmental factors such as temperature.

	PROTEIN:	FAT:	CARBS:	ENERGY:
Beef (ground)	25g	6g	0g	156kcal
Grasshopper	31g	7g	16g	185kcal
Chicken (breast)	24g	3g	0g	131kcal
Silk worm	20g	6g	4g	254kcal
Cricket	28g	6g	6g	206kcal
Pork (chop)	28g	13g	1g	232kcal





# ARTIFICIAL MEAT

You could be eating flesh grown in a test tube rather than on a farm

IN VITRO BURGERS, laboratory-grown steaks or engineered beef patties? Scientists haven't quite settled on the right name yet, but whatever you call it, artificial meat appears to be coming our way. Last year, Professor Mark Post of Maastricht University unveiled the world's first artificial burger. With a price tag of €250,000 (£211,000) these high-tech feasts are not yet commercially viable, but Post predicts they will quickly become affordable as the world struggles to keep up with the demand for meat.

Post's famous €250,000 burger was grown from bovine muscle stem cells, harvested through biopsy and cultured in a medium containing foetal calf serum – essentially blood with the red cells removed. The serum contained the nutrients required for the cells to differentiate into mature muscle cells.

The slivers of muscle were then stretched between two Velcro anchor points such that their innate tendency to contract caused them to bulk up into small strands of meat. Electrical impulses were also passed through the muscle to increase its protein content. Three thousand small pieces were fused to create one standard-sized burger.

Post's is one of an increasing number of groups aiming to bioengineer meat. The US start-up, Modern Meadows, run by Professor Gabor Forgacs and his son Andras is using 3D-printing technology to produce living tissue, ultimately aimed at creating artificial organs as well as meat.

Here, thousands of live muscle stem cells are loaded into a cartridge – a sort of biological

## NUTRIENT CONTENT

Per 115g of natural-tasting artificial burger

PROTEIN:	5.1g
FAT:	5.6g
CARBOHYDRATE:	0.3g
ENERGY:	73kcal

ink – and once printed into the desired shape, the cells naturally fuse together to form living tissue. The pair describe the taste of their most recent production as “not unpleasant”, but admit it still needs refinement.

But will consumers be willing to eat artificial meat? “We manage to get over the ‘yuck factor’ of slaughter houses and factory farming feedlots,” says Andras. “The process behind cultured meat is much cleaner, much more transparent and much better for the environment and animals than conventional animal farming.”



## ALTERNATIVE MEATS

Can't wait for artificial flesh? Tuck into these in the meantime



### OSTRICH

This bird produces meat with similar protein and iron levels to beef. It also has a tiny fat content of 0.5 per cent – less than half that of chicken breast. Ostrich

produce 30 to 60 chicks a year for 40 years, making them a high-yield livestock.



### DEER

Thanks to a collective case of ‘Bambi syndrome’, Britain's deer population is spiralling out of control. According to University of East Anglia scientists, who

published a recent survey of the deer population, around 750,000 need to be killed each year to contain the population. “We’re talking about pest control, but it’s also about putting venison on the family table,” said Dr Paul Dolman, who led the survey.



### HORSE

Horseburgers may have gone down badly with the public, but they could be a healthier choice. Horsemeat is leaner than beef, pork and

lamb, and a study by nutritionists at the University of Milan published earlier this year found that people who ate horse regularly had higher levels of iron and healthy omega-3 fatty acids in their blood and lower levels of cholesterol than a control group. Although relatively poor converters of grass and grain to meat compared to cattle, horses are working animals and meat is a bonus by-product.

Fancy some? Prof Mark Post with samples of his in vitro meat





# FRUIT & VEG

We'll need new technology if we want to keep eating five a day

## → GM GREENS

IN THE GLOBAL production of staple foods, potatoes come in fourth (after corn, wheat and rice) with an annual production of around 314 million tonnes. But in terms of yield, the humble tuber is the easy winner, producing nearly six times as many tonnes per hectare as wheat. With more than half of the world's potatoes grown in developing countries, the UN is promoting the potato as a more efficient crop that could improve global food security. But there is a major stumbling block: blight.

The fungus-like organism, *Phytophthora infestans*, which caused Ireland's famine of the 1840s, continues to decimate crops today. Last year, up to 20 per cent of European potatoes were lost to blight and many farmers were forced to spray crops with fungicides 15-20 times at a cost of around £500 per hectare.

Scientists at Britain's Sainsbury Laboratory are working on a cheaper and potentially more sustainable solution. Behind an alarmed fence near Norwich, they are testing potatoes genetically modified to be blight resistant. Professor Jonathan Jones, the lead scientist,



describes GM as equivalent to adding an app to an iPhone. "It's still the same phone, but you're giving it extra functionality," he says.

After screening hundreds of varieties, Prof Jones's team isolated genes that give blight resistance to two wild, inedible potato species from South America. Early results suggest that inserting these genes into a Désirée variety can successfully confer blight resistance, without the need for fungicides.

GM can not only improve the hardiness of crops, but also their healthiness. Professor Cathie Martin at the John Innes Centre in Norwich has developed a variety of purple tomatoes with high levels of pigments called anthocyanins throughout the flesh and skin. These compounds, normally found in berries such as blackberry and blueberry, appear to offer protection against certain cancers,

**"GM can not only improve the hardiness of crops, but also their healthiness"**



The potato blight fungus is hitting our food supply hard

cardiovascular disease and dementia.

Tomatoes are so widely consumed that they represent a vehicle to introduce beneficial properties to those who can't afford, or don't have access to, expensive, seasonal berries. "You would need to consume only one or two tomatoes to get equivalent levels of anthocyanins to those in a punnet of berries," says Prof Martin.

In a preliminary study, with cancer-susceptible mice, a diet supplemented with purple tomatoes rather than standard ones increased lifespan by nearly a third. Martin is now planning a randomised controlled trial to test their health benefits in humans.

"Acceptance of any food of a new colour can be problematic," says Martin, citing the failed green ketchup marketing ploy, but she remains optimistic that consumers will react to purple tomatoes in a similar way to coloured salad leaves. It might just be the GM bit that's a problem.

You say tomato,  
I say genetically  
modified purple  
tomato

## NUTRIENT CONTENT OF GM PRODUCE

	PROTEIN:	FAT:	CARBS:	ENERGY:
GM Désirée potatoes (per 115g)	2g	0g	17g	84kcal
Purple tomatoes (per 100g)	0.8g	0.5g	3.5g	19.5kcal





## SEAWATER GREENHOUSE

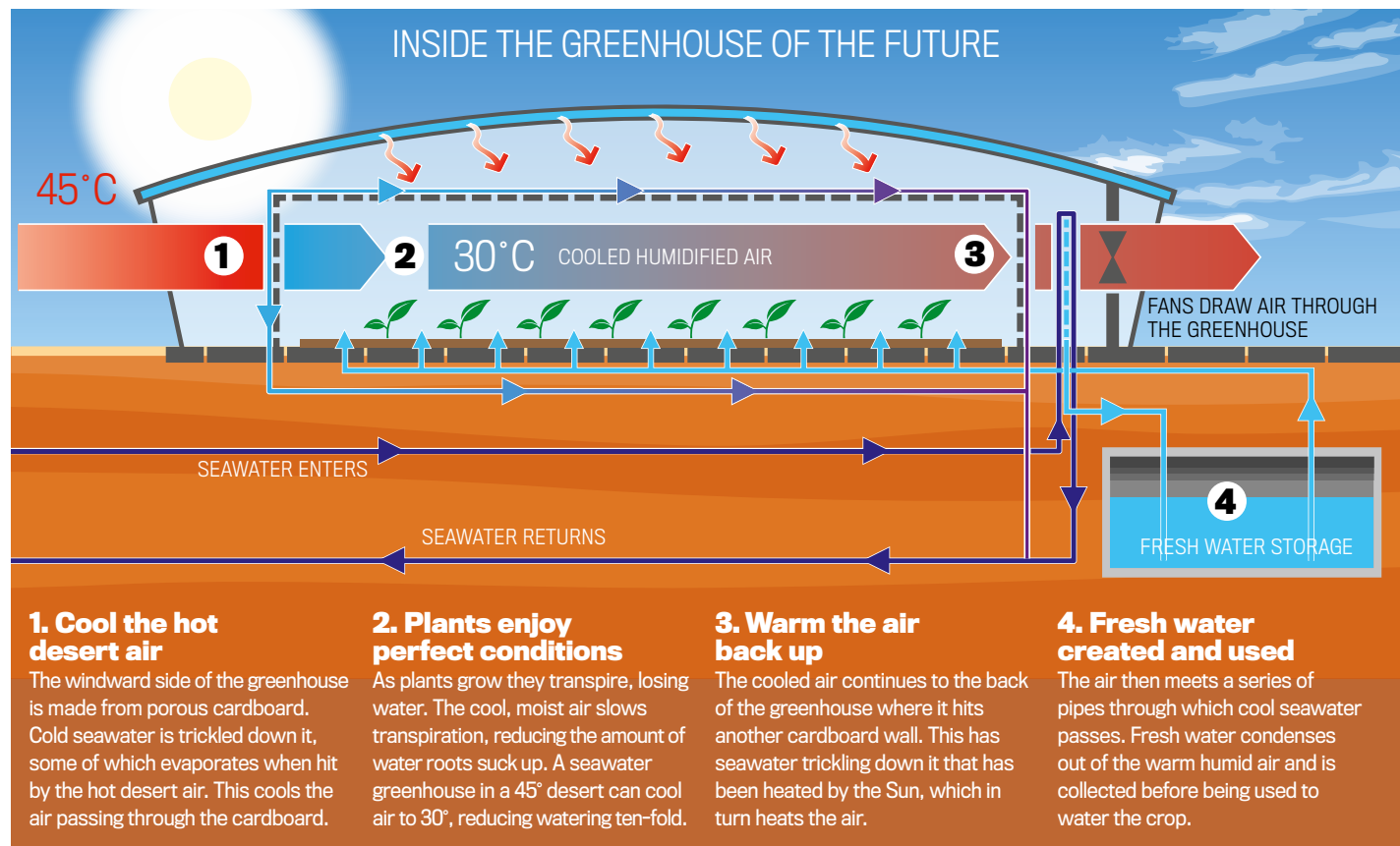
GREENHOUSES TRAP THE Sun's heat to produce greater crop yields and allow unseasonal growth. So why would you put them in the desert? British inventor Charlie Paton has turned the concept on its head to allow farmers in the driest and hottest parts of the world to grow fruit, vegetables and herbs. More extraordinary still, the water piped to the growing plants by his

system comes from the sea. "The potential for food growth is practically unlimited," says Paton. "We can grow crops such as tomatoes, lettuces and cucumbers in places such as Oman or the UAE where it would otherwise not be possible."

For the process to work efficiently, air must be constantly sucked through the greenhouse. In some locations this requires fans. The technology is most effective in sites by the sea and in hot, dry deserts such as those in North Africa, the Middle East, Australia, Mexico and

China. Energy for pumping and fans can be generated using solar power.

Pilot seawater greenhouses have been built in Tenerife, Abu Dhabi and Oman. The most advanced project is at Port Augusta, 200 miles north of Adelaide, Australia. Paton says that tests at the 2,000m<sup>2</sup> greenhouse show the process can match the 80kg of tomatoes per square metre per year grown in modern agricultural greenhouses in Holland. This site is due to be extended 40-fold this year.



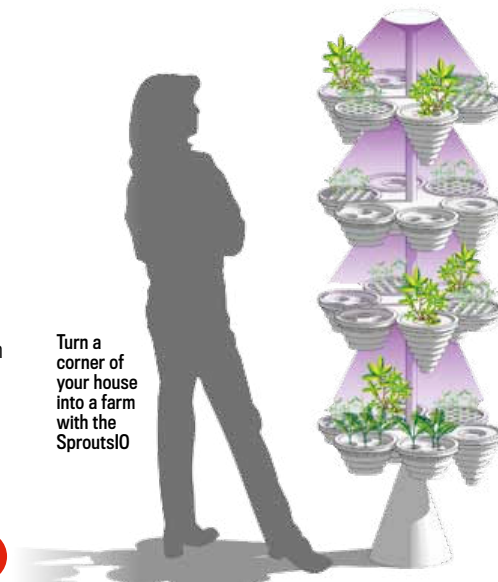
## INDOOR GROWING PODS

THERE'S NO NEED for a large plot of land or a spade if you want to grow veggies – a new piece of kit enables anyone to become a small-scale farmer. With the SproutsIO Microfarm there's not even a need for messy old soil – plants grow in a nutrient mist that wafts over them. The brainchild of Jennifer Broutin Farah, a graduate student at MIT's Media Lab in the US, she hopes SproutsIO will become a ubiquitous part of the urban scene, with city dwellers growing the likes of tomatoes and potatoes in its planting pods. It would mean that veggies are grown where they are consumed rather than having to be transported hundreds of kilometres.

As well as replacing soil with the nutrient mist – an 'aeroponic system' – SproutsIO packs an array of sensors that collect temperature, humidity, pH and light data, adjusting settings automatically to keep plants in tip-top condition. The data is fed to an app, so urban farmers can keep track of their aubergines from their phone or tablet as they sit at their office desk, kilometres away.

"There are lots of benefits to growing plants in an aeroponic environment," says Broutin Farah. "It uses 98 per cent less water and 60 per cent less fertiliser than soil production, and because it's indoors, you can grow all year round." She hopes SproutsIO will soon start popping up in flats and houses. "We're currently at the prototype stage but our system could be ready in a year."

Turn a corner of your house into a farm with the SproutsIO







# ALGAE

How the green slime will become a foodstuff

➔ RISING OIL PRICES have led to a boom in research into growing algae as a fuel source. But in the future we may be using it to fuel our bodies too. In the hot, semi-arid outskirts of Karratha, Western Australia, are six acre-sized ponds surrounded by 38 smaller satellite ponds, each gently bubbling away. According to Aurora Algae, the US company that owns the site, this is what the future of farming looks like. Aurora Algae is pioneering the cultivation of green slime and says it could help to solve the future food crisis.

There are several points in favour of algae as a foodstuff. Fresh water and fertile farmland are already in short supply, with global demand for water projected to increase by 55 per cent by the middle of the century, according to the Organisation for Economic Co-operation and Development. Algae is rich in protein, grows all year round and can be harvested daily. Not only that, it also consumes climate-bothering carbon dioxide. It is already on the market as a foodstuff, albeit a slightly niche one, in the form of green pasta and energy bars.

Paul Brunato, Aurora's vice president of corporate affairs, concedes that "the mass market may not be quite ready to embrace

'whole' algae as a food source." He adds that the first commercial applications are likely to be mixing algal powder with other products, including animal feed, to supplement the nutrients including protein, omega-3 essential fatty acids and carbohydrates.

In its six test ponds, Aurora is already producing 30 metric tonnes of dried algae per acre – that's up to 40 times as much protein per acre compared to soybeans, using one per cent of the water soybeans need. The company expects to be producing on a commercial scale by 2015 at a new facility in New South Wales using 50, five-acre ponds.

While algae grows quickly, growing it commercially is tricky. It absorbs far more light than it can convert into chemical energy, meaning that layers close to the surface quickly block off the light required by those lower down. After a screening program, Aurora selected wild strains that absorb the least light, meaning they can be grown in dense blooms in shallow ponds.

The company is now looking into how best to market it. "We are considering products ranging from protein powder for mixing with other foods and drinks, to protein-rich snack bars, and algal protein flour for baking," says Brunato.

**"Aurora is pioneering the cultivation of green slime and says it could help solve the food crisis"**

## NUTRIENT CONTENT

Per 115g of Aurora's proprietary strains of *Nannochloropsis* algae

PROTEIN:	48.3g
FAT:	11.5g
CARBOHYDRATE:	41.4g

PHOTO: AURORA PHOTOGRAPHIC LIBRARY, CORBIS



The future of food is taking on a green hue at Aurora's huge Australian algae farm



# WHAT HAPPENED TO THE FOOD PILL?

Completely replacing meat and two veg with tablets is impossibly complex

GEORGE, JANE, JUDY and Elroy no longer had to bother with cooking and washing up; in the year 2062 they got all the prime rib eye steak, fried chicken and pizza they wanted in the form of a pill. The Jetsons were fictional characters of an animated series, first broadcast in the 1960s, and despite the best efforts of numerous science fiction authors and futurologists, scientists have long dismissed the notion of whole meals in a pill.

There are some formidable barriers. The average British man needs to consume around 2,500 calories a day, while the average daily requirement for women is closer to 2,000 calories. Nutritionists recommend a variety of ratios of different energy sources. UK athletics coach Brian Mackenzie, for example, recommends 57 per cent carbohydrates, 30 per cent fats and 13 per cent protein. Fat, the most concentrated food source, has around nine calories per gram, while carbohydrates and protein contain about four calories per gram.

Large pills weigh around a gram, meaning that using this calorie-source ratio, the average man would need to take at least 521 pills and the average woman 417 pills daily, just to meet their basic energy requirements. This does not include the vitamins, minerals and other key nutrients that play important roles in our diets.



If you think Chinese food is difficult with chopsticks, wait till you try these

"To get enough of these and the other things you need in pill form, you'd have to spend most of your day taking them," says Marion Nestle, the Paulette Goddard Professor of Nutrition, Food Studies and Public Health at New York University.

It would take a radical breakthrough to bypass these problems. It's no surprise then that instead of trying to make food redundant, the US military's research arm DARPA has been funding research that would mean that soldiers would be able to operate for long periods without eating.

In 2004, DARPA offered grants under its 'Metabolic Dominance' programme. Its launch

document described how the agency wanted to achieve 'continuous peak physical performance and cognitive function for three to five days, 24 hours per day, without the need for calories'.

Ways to achieve this, according to DARPA, might include making soldiers' bodies temporarily metabolise their own fat reserves. No such solutions have so far been developed... or at least none have been made public. ■

**WHAT DO YOU THINK?**  
Which of these future foods sounds palatable and which leaves a bad taste in your mouth?  
reply@sciencefocus.com

## IF YOU THINK FUTURE FOODS SOUND REVOLTING...

...take a look at what you're already eating



### BEAVER ANAL GLANDS

TV chef Jamie Oliver caused uproar when he

dropped this bombshell on the *David Letterman Show*: "Did you know that there are beaver's anal glands in vanilla ice cream?" They're used to enhance flavour, he said. Ice cream makers swiftly issued denials. But according to *Fenaroli's Handbook Of Flavor Ingredients*, the annual US consumption of the beaver secretion is around 136kg!



### HUMAN HAIR AND POULTRY FEATHERS

When hairdressers

sweep up those hair clippings, where do they end up? Possibly on your dinner plate, in the form of L-cysteine. This amino acid, which gives hair its strength, is sometimes used to give bread 'bounce' and enhance savoury flavours. If you're concerned about the cannibalistic overtones, don't worry - it can also be taken from poultry feathers.



### FISH SWIM BLADDER

Isinglass, the substance that makes up the

fish swim bladder, is used in the brewing industry to accelerate the clarification of beer - from real ales to lagers. Powdered isinglass is poured into casks where it brings the live yeast out of its suspension in the beer and turns it into a jelly-like mass, which settles at the bottom. Brewers say only traces of fish bladder make it into your pint.



### APHIDS, COPEPODS AND RODENT HAIRS

According

to US Food Standards Agency legal limits, consumers can expect up to 30 aphids in 100g of Brussels sprouts, up to four rodent hairs in 25g of curry powder, and a 'copepod' [a small crustacean found in freshwater and the sea] accompanied by pus pockets' in three per cent of their red fish filets.



### WAXY SHEEP SECRECTIONS

Next time you pop some chewing gum

in your mouth, consider this - it may well contain lanolin, the yellow waxy substance secreted by the sebaceous glands of sheep. It's added to gum to soften it.

HANNAH DEVLIN is Science Editor of *The Times*; Nic Fleming is a science journalist

# Bowers & Wilkins



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# Q&A

## YOUR QUESTIONS ANSWERED

BY OUR EXPERT PANEL



**SUSAN BLACKMORE**

Susan is a visiting psychology professor at the University of Plymouth. Her books include *The Meme Machine*



**DR ALASTAIR GUNN**

Alastair is a radio astronomer at the Jodrell Bank Centre for Astrophysics at the University of Manchester



**ROBERT MATTHEWS**

After studying physics at Oxford, Robert became a science writer. He's a visiting reader in science at Aston University



**GARETH MITCHELL**

Starting out as a broadcast engineer, Gareth now writes and presents *Digital Planet* on the BBC World Service



**LUIS VILLAZON**

Luis has a BSc in computing and an MSc in zoology from Oxford. His works include *How Cows Reach The Ground*

EMAIL YOUR QUESTIONS TO [questions@sciencefocus.com](mailto:questions@sciencefocus.com)

or post to *Focus* Q&A, Tower House, Fairfax Street, Bristol, BS1 3BN

**Q** SARAH HARRIS, KINGS LYNN

### What is the largest animal that can run on water?

**A** FEW ANIMALS CAN run on water because it's very energy-intensive. Insects like the *Gerridae* pond skaters are light enough to be supported by surface tension. At least one lizard, the Brazilian pygmy gecko, can also do this but it is tiny – less than 4cm long. Basilisk lizards are nearly twice as long

and weigh around 80g, but can make short sprints across water by using webbed feet to push the water down fast enough to create an upward force that balances their weight. In effect, they are swimming with such a vigorous stroke that their body is lifted clear of the water. **LV**



It makes *Dancing On Ice* seem a bit trivial

PHOTO: STEPHEN DALTON/PHOTOSHOT



## In Numbers

# \$100m

The sum the US is investing in the BRAIN project to map the human brain, in an attempt to treat diseases like Parkinson's and Alzheimer's.

**Q** RUBEN WAUTERS, FAREHAM

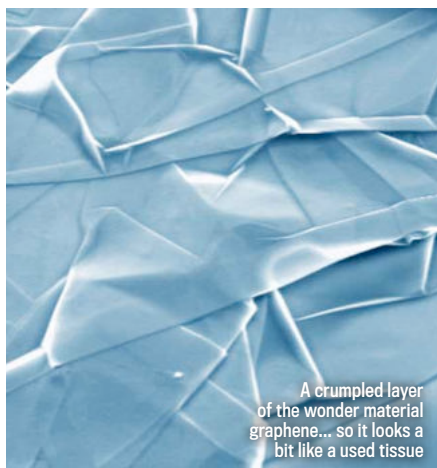
## Why doesn't the Moon have an atmosphere?

**A** THE MOON HAS an atmosphere, it's just very thin compared to Earth's – 100 trillion times less dense, in fact. A planet or moon retains an atmosphere if the pull of its gravity can overcome the natural motions of atoms and molecules in its vicinity. Because the Moon has only one-sixth of the Earth's gravity, it is unable to hold on to most atoms and molecules that would otherwise form an atmosphere. Most (but not all) of these atoms and molecules have easily escaped into space. **AG**

**Q** JENNY RICHARDSON, DUNGARVAN

## What does a sheet of graphene look like?

**A** GRAPHENE IS MADE up of hexagonal patterns of carbon atoms, rather like chicken wire. Tiny sheets of the stuff can be created simply by applying sticky tape to slivers of graphite and peeling it off. But being only one atomic layer in thickness, the layer has to be stuck to special film in order to be seen. **RM**



A crumpled layer of the wonder material graphene... so it looks a bit like a used tissue

**Q** SEBASTIAN DILL, BERMUDA

## How do jellyfish reproduce?

**A** THERE ARE A few jellyfish species that receive sperm through their mouths to fertilise eggs inside the body cavity, but most jellyfish just release sperm or eggs directly into the water. Under favourable conditions they will do this once a day, usually synchronised to dawn or dusk.

The fertilised eggs hatch into tiny free-swimming flatworms called planulae, which either develop directly into adult jellyfish or settle on rocks to form an intermediate polyp stage. The polyps can then reproduce asexually by budding off tiny jellyfish one or two millimetres across, which feed on plankton and gradually grow into full-size adult jellyfish. **LV**

A jellyfish surrounded by its eggs; the gelatinous creatures have a bizarre reproductive cycle



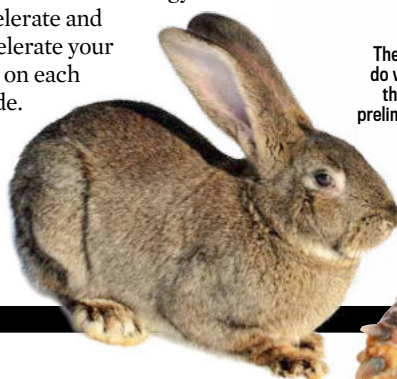
**Q** TERRY HASTINGS, LEEDS

## What's more energy efficient - walking fast or running slow?

**A** BOTH WALKING AND running have an optimum speed. When you walk, each foot touches the ground for the full stride, so your legs are mostly fully extended, swinging like pendulums. A pendulum has a natural frequency and walking faster than that needs extra energy to accelerate and decelerate your legs on each stride.

At a certain speed, running takes less energy because your legs touch the ground only briefly and fold up for the return stroke. Bending shortens the effective length of the pendulum and lets you swing your legs faster. But at low speeds, the up-and-down movement of your legs and body consumes more energy than it saves.

A recent study at Ohio State University found that humans tended to alternate between running and walking when covering a distance just over the length of a football field, which suggests this is the most efficient compromise between speed and energy. **LV**



The hare would do well to avoid the tortoise in preliminary heats

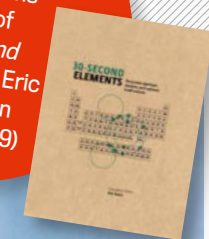




## QUESTION OF THE MONTH

WINNER!

Bernard wins  
a copy of  
30-Second  
Elements by Eric  
Scerri (Icon  
Books, £12.99)



The wet stuff could  
have crash-landed on  
Earth in comets

0 BERNARD WILSON, BRISTOL

## Where did Earth's water come from?

**A** THE ORIGIN OF the 1,450 million billion tonnes of water in the world's oceans is something of a mystery. Explanations divide into two camps: endogenous, meaning the water came from the Earth itself, and exogenous, meaning it was dumped here from elsewhere.

For example, one endogenous possibility is that water molecules were formed from hydrogen and oxygen molecules combining inside the early Earth, and emerging as steam in volcanic eruptions. Alternatively, ready-made water molecules may have

been delivered here by comets, which are known to contain water-ice and are believed to have bombarded the primordial Earth.

Until recently, astronomers were sceptical of the comet theory, as it could not explain the fact that around 0.3 per cent of oceanic water contains an unusual form of hydrogen called deuterium. However, in 2011, astronomers found deuterium-based water on comet Hartley 2. While not proof that we've all been drinking comet debris, it keeps this intriguing possibility alive. **RM**



Chillies: the pain  
(and pleasure)  
of mammals

0 LUKE AZZOPARDI, MALTA

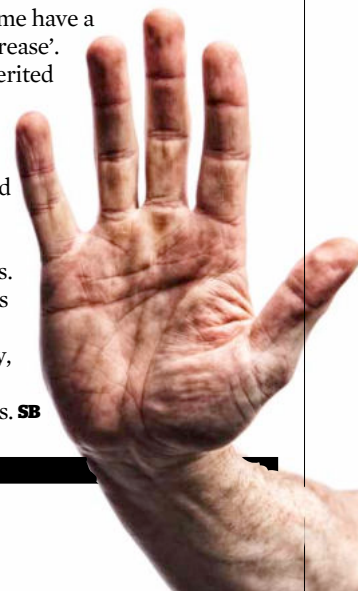
## Why are chilli peppers so hot?

**A** THE CHILLI PLANT produces the chemical capsaicin to discourage herbivores from eating the peppers. Mammal teeth destroy chilli seeds but birds swallow them whole and help the plant to spread, so the plant has evolved a chemical defence system that is irritating to mammals but has no effect on birds. **LV**

0 SERGIO DE SOUZA, LONDON

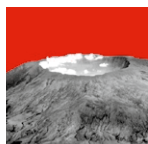
## Why do we have lines on the palms of our hands?

**A** SO THAT WE can scrunch our hands into a fist, or other complex shapes, without excessive stretching or leaving bags of loose skin – think about how much movement occurs when you're typing, holding a cup or doing chores. The lines are called 'palmar flexion creases' and develop before birth. Most people have two main lines across the palm but some have a single 'Simian crease'. This can be inherited normally on either one or both hands, but is also associated with Down's syndrome and other conditions. Palmistry claims the lines reveal your personality, but there is no evidence for this. **SB**



## TOP TEN

### DEADLIEST VOLCANIC ERUPTIONS



#### 1. Tambora, Indonesia

Year: 1815  
Death toll: 92,000



#### 2. Krakatoa, Indonesia

Year: 1883  
Death toll: 36,000



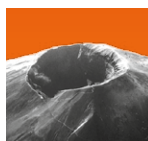
#### 3. Mt Pelée, Martinique

Year: 1902  
Death toll: 29,000



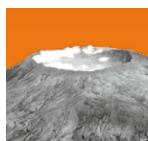
#### 4. Nevado del Ruiz, Colombia

Year: 1985  
Death toll: 23,000



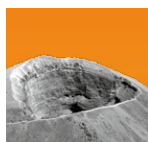
#### 5. Unzen, Japan

Year: 1792  
Death toll: 15,000



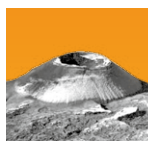
#### 6. Kelut, Indonesia

Year: 1586  
Death toll: 10,000



#### 6. Vesuvius, Italy

Year: 79AD  
Death toll: up to 10,000



#### 8. Laki, Iceland

Year: 1783  
Death toll: 9,350



#### 9. Vesuvius, Italy

Year: 1631  
Death toll: 6,000



#### 10. Santa Maria, Guatemala

Year: 1902  
Death toll: 5,000



An edible Space Shuttle courtesy of a 3D printer at Cornell University

**Q** CLARE RAYNES, DERBY

## Can 3D printers be used to make food?

**A** AT CORNELL UNIVERSITY in the US, they are already 3D printing food, albeit nothing very appetising. The ingredients are anything that can be squeezed through a syringe in the print head, such as peanut butter, icing and pasta. Because food is more viscous than plastic, it's important to get the consistency right or your beautifully

crafted shape soon sinks into a nondescript mess. The Cornell team get around this by making edible objects that are 4-5cm across. They make small tortillas by pushing dough through the syringe, gradually building shapes like stars.

They've also made artificial mushrooms, bananas and mozzarella, and are working on edible gels called hydrocolloids. The stuff is transformed from gloop to grub as the printer adds flavoured compounds to create varying tastes and textures. **GM**

**Q** ALEX DAKIN, SWITZERLAND

## Why do we yawn?

**A** NO-ONE IS sure why we yawn. We do know that yawning increases with levels of some of the brain's neurotransmitters, including dopamine and serotonin, and decreases with levels of the opium-like endorphins.

One theory as to what triggers a yawn is that the long inhalation and short exhalation bring in more oxygen and reduce carbon dioxide, which might explain why we yawn when we are tired, bored or stuck in a stuffy room. But in fact, yawning is not an

Reading rival science magazines isn't the best way to avoid yawning

efficient way to increase oxygen levels, nor does giving people extra oxygen stop them yawning.

Other theories invoke temperature control, either of the whole body or just of the brain, which is especially sensitive and needs a steady temperature to function.

Yet another theory is that the stretching that often accompanies yawning (doing both at once is called 'pandiculation') keeps us ready for action.

Infectious yawning is also thought to keep whole groups of animals alert together and synchronise their sleeping and waking. **SB**







The vestibulo-ocular reflex assists you in the taxing task of tackling tack traps

**Q** DEREK SMYTH, IRELAND

## How do you keep your eyes focused when walking?

**A** YOUR EYES ARE connected by a series of reflex nerves to the sense organs of the inner ear and the stretch receptors in your neck muscles. As you move your head, your eyes automatically compensate by moving in the opposite direction – this occurs even in pitch darkness. This

‘vestibulo-ocular reflex’ helps to stabilise the visual field.

There is also something called the ‘optokinetic reflex’, which causes your eyes to lock onto a moving subject and smoothly track it for a while before snapping back to the centre. **LV**

### WHAT IS THIS?



#### KNOW THE ANSWER?

Go to [sciencefocus.com/qanda/what](http://sciencefocus.com/qanda/what) and submit your answer now!

#### LAST MONTH'S ANSWER:

Well done to Nejc Draganjec, who correctly guessed bio-minerals in a sea urchin tooth.

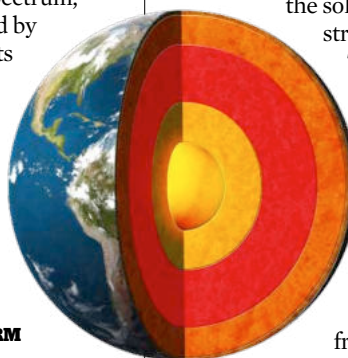
**Q** KATE WATTS, BY EMAIL

## What colour is a mirror?

If this looks like you, you're either a vampire or in a snowstorm



**A** IN WHITE LIGHT, which includes the wavelengths of the visible spectrum, the colour of an object is dictated by those wavelengths of light that its surface atoms fail to mop up. As a perfect mirror reflects back all the colours comprising white light, it's also white. That said, real mirrors aren't perfect, and their surface atoms give any reflection a very slight green tinge, as the atoms in the glass reflect back green light more strongly than any other colour. **RM**



### ? Did you know?

In 2010, farms produced 68.9 million tonnes of eggs, enough to make an omelette the size of Northern Ireland.



**Q** JAIME MARTIN, BY EMAIL

## Why do we get bored?

**A** LIKE HUNGER, THIRST and loneliness, boredom is a negative feeling that drives us to change our behaviour. Natural selection has favoured individuals with the capacity to feel bored because they are more likely to discover or create things that improve their survival chances, or to look for a new partner and so spread their genes more widely. Contentment leads to complacency, and that's a dangerous evolutionary strategy. **LV**



**Q** ADAM DOOLEY, MANCHESTER

## What would happen if Earth's core cooled?

**A** THE EARTH'S CORE has a solid inner portion, surrounded by a liquid outer core that's 2,266km thick. Convection currents in the outer core are what generate Earth's magnetic field. If the core cooled and solidified, the magnetic field would drop to almost nothing and the charged particles of the solar wind would be free to strike the upper atmosphere. This could strip away the ozone layer and expose us to lethal ultraviolet levels. You might be surprised to know that the outer core is actually freezing. But the rate is only about 1mm per year, so it will take 2.2 billion years to freeze completely. **LV**



Q MATT WAUGH, FAREHAM

## How do we know how hot the Sun is?

**A** THE SUN IS a scorching 5,500°C. There are several ways that we can measure its temperature. First, we can measure the amount of radiation hitting Earth and use the Sun's distance and size to calculate how hot it must be. The Sun's light also has a particular spectrum and its shape, as well as the wavelength of light where most energy is emitted, reveals the Sun's temperature.

But the most accurate method relies on the fact that elements in the solar atmosphere absorb radiation. Which wavelengths are absorbed, and by how much, also depends on the temperature. The temperature at the centre of the Sun can be calculated using our knowledge of nuclear physics. It's a sweltering 15.7 million degrees Celsius. **AG**

Q HARIS AMIRI, TWITTER

## Could a brain transplant give you someone else's memories?

**A** THERE'S NO SUCH thing as a brain transplant. Not just because we don't currently have the technique, but because putting someone else's brain in your body would result in them getting a body transplant, not you getting a brain transplant! Your body would have their memories, but it would also have their personality – 'you' wouldn't get their memories because 'you' wouldn't exist any more. Transplanting just part of their brain

wouldn't work either, because memory is distributed among lots of different regions of the brain. Virtually every part has some role to play in storing or processing memories. **LV**

Cate Blanchett as Bob Dylan in *I'm Not There*; the closest we'll get to a brain transplant

Q AMBER DENNESS, FAREHAM

## Why is there no oxygen in space?



Ed White, the first American to walk in space, wouldn't have wanted to take his helmet off

**A** THERE IS OXYGEN in space.

In the vicinity of the Sun, for example, there are about 50 oxygen atoms in every cubic metre of space. Although only about 100-billion-trillionths of the density of oxygen in the Earth's atmosphere, that's quite an abundance of oxygen on a cosmic scale. Oxygen is the third most common element in the Universe, but accounts for just 1 per cent of all matter. By contrast, the Earth itself is about 30 per cent oxygen, the atmosphere is about 21 per cent oxygen and we humans are composed of about 65 per cent oxygen.

So why is oxygen so much more abundant on Earth? This is because when the Sun was first formed, its radiation swept away most of the lighter elements, such as hydrogen and helium, enriching the primitive Earth with oxygen. The presence of life on Earth also ensures there is plenty of free oxygen in the atmosphere. Perhaps 70 per cent of all oxygen in Earth's atmosphere is made by marine algae! **AG**

Q MARTIN GREEN, FAREHAM

## What evolutionary benefit does religion have?

**A** FROM GENES' POINT of view, religions can be brilliant because they encourage large families. One study across 82 countries and many religions found a strong correlation between religious observance and family size,

with frequent worshippers averaging 2.5 children per woman and non-worshippers only 1.7. In a study of Jews, the orthodox had far more children than atheists, and the ultra-religious Haredim in Israel averaged six to eight children.

Other possible evolutionary benefits include enforcing social cooperation and restricting women's freedom, which ensures that men are bringing up their own children. Religions also encourage altruism towards their own members and sometimes hostility towards others, with any wars that ensue benefiting the winners' genes. **SB**

Worshippers at the Vatican probably come from larger families than atheists







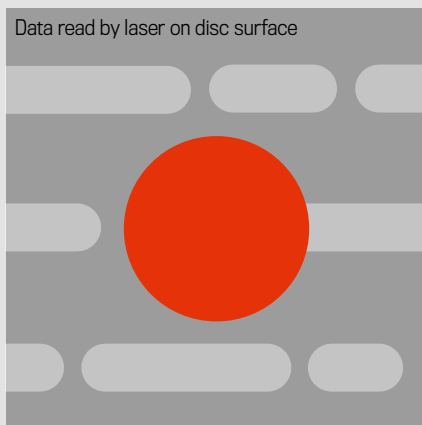
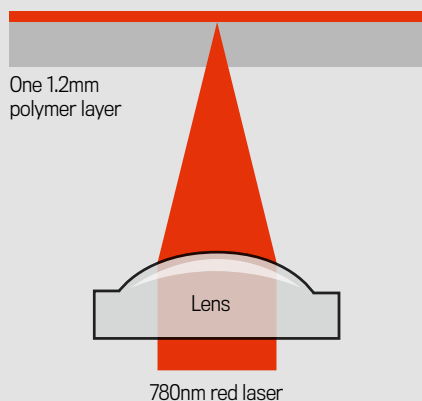
## HOW IT WORKS

# BLU-RAY DISC

YOU MIGHT HAVE enjoyed the high-definition (HD) quality of Blu-ray films such as *Avatar* on a big TV. If not, you're missing out. Blu-ray discs were designed to replace DVD, with a higher capacity for data enabling HD video. The name Blu-ray is derived from the blue laser used to read the disc. This allows data to be stored at a higher density than is possible with the longer-wavelength red lasers used for DVD and CD.

The information density of the DVD format was limited by the wavelength of the lasers used. Following the development of new technology, primarily at Sony, blue lasers operating at 405 nanometres (nm) became available, replacing the 650nm red lasers used in DVD player. This means that more information about a film can be stored on a disc, leading to crisper, more detailed footage.

## CD

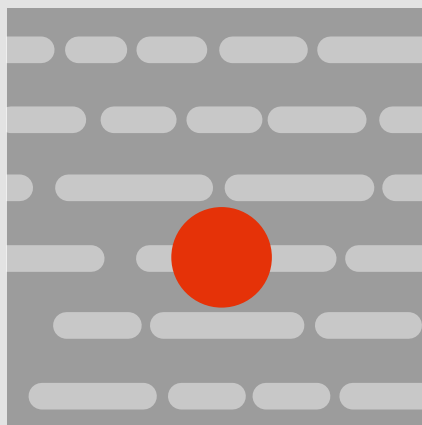
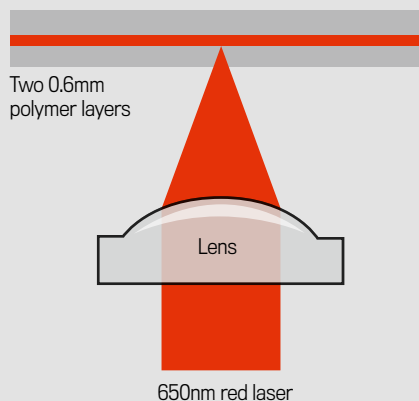


### CAPACITY

0.7GB

Over 200 billion CDs have been sold

## DVD

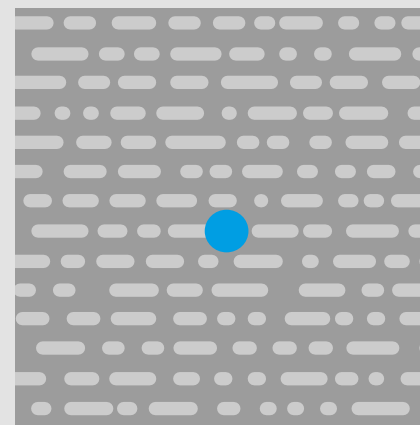
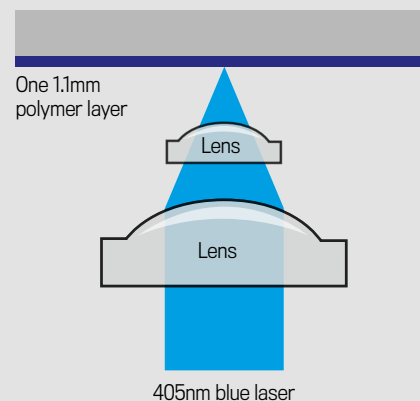


### CAPACITY

4.7GB

Data on DVD can last from 30 to 100 years

## BLU-RAY



### CAPACITY

25GB

Will Blu-ray be the last disc format? See p82

# THE NIGHT SKY: WHAT CAN I SEE IN JUNE?



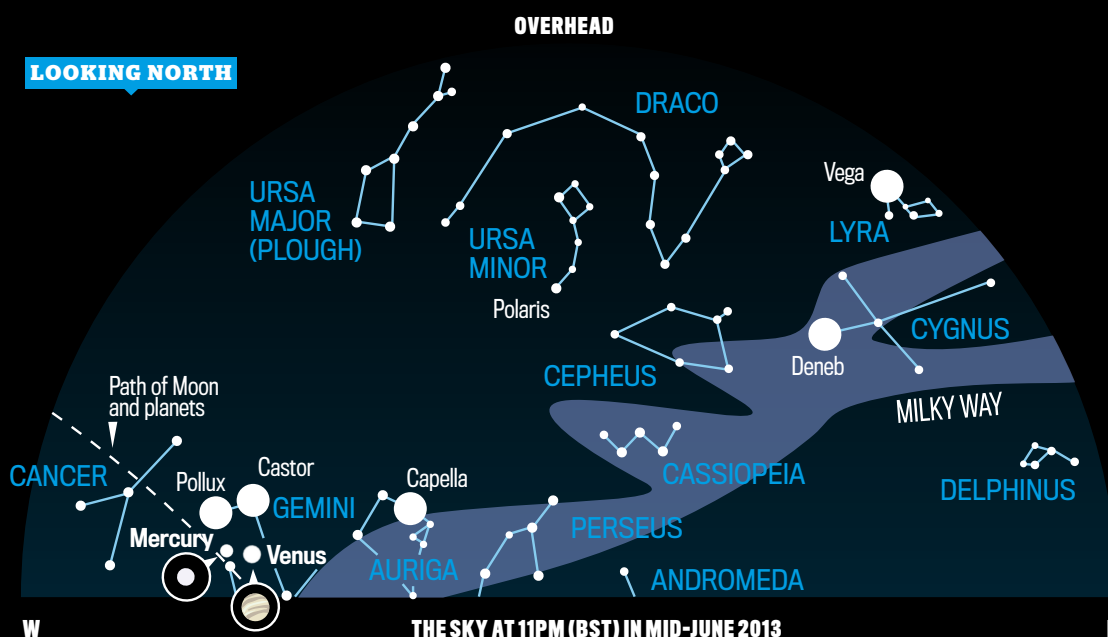
Don't miss *The Sky At Night* on BBC One every month  
[www.bbc.co.uk/skyatnight](http://www.bbc.co.uk/skyatnight)

Astronomy with  
 Heather Couper  
 and Nigel Henbest



**SUMMER'S HERE – OFFICIAL!** On 21 June, we hit the Summer Solstice, when the days are longest and the nights shortest. The summer constellations of Lyra, Cygnus and Aquila are hoving into view, while Boötes and Corona Borealis hog centre stage. Catch Venus and Mercury just after sunset, and also Saturn. The ringed planet is a stunning sight through a small telescope, and there are so many good, affordable scopes available now that there's no excuse not to ogle it!

## LOOKING NORTH



## LOOKING NORTH

**11 June, about 10.30pm**

Look low on the north-west horizon to spot a thin crescent Moon. The bright object to its right is Venus, and the 'star' between them is a rare appearance of Mercury.

**21 June, 6.04am**

Crack out the champeres: it's the Summer Solstice, when the Sun hovers over its most northerly point on Earth.

## LOOKING SOUTH

**All month, all night**

Antares – a red supergiant 15 times more massive than the Sun – makes its best appearance low in southern skies this month.

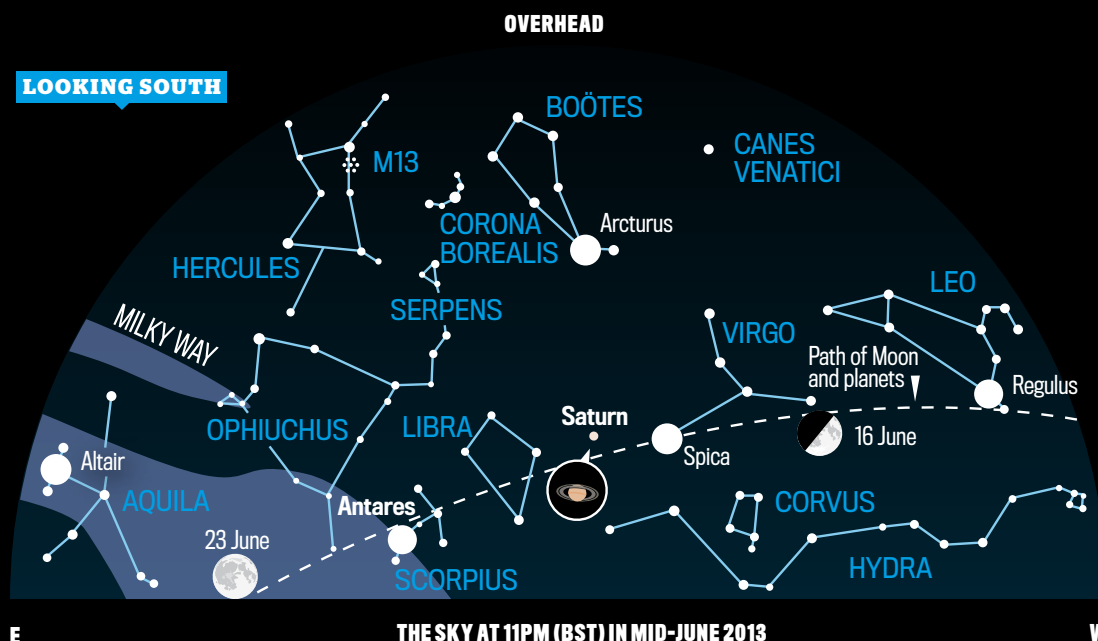
**All month, all night**

The faint constellation of Hercules is blessed with fascinating objects. The globular cluster M13 is just visible to the unaided eye in dark skies, and 11 of its stars are also home to exoplanets.

**23 June, all night**

The Full Moon, close to the southwest horizon, will look huge tonight. The Moon always seems bigger near the horizon, but this month it's also at its closest to the Earth, making it appear even bigger and brighter.

## LOOKING SOUTH



## Find out more



**Stargazing 2013**  
 Discover astronomy with Heather Couper and Nigel Henbest (Philip's, £6.99)



Q PRANEETH VITHARANA, SRI LANKA

## Why do we need leap years?

**A** THE EARTH TAKES a fraction over 86,400 seconds to complete a revolution around its own axis (one day). It takes about 365.25 times as long to complete an orbit around the Sun (one year). If you just round the calendar year down to the nearest whole number, the date recorded by the calendar will drift out of sync with the seasons.

The ancient Egyptians had a 365-day calendar with exactly this problem and in 238BC, pharaoh Ptolemy III issued a decree extending the New Year ceremonies, every fourth year, from five days to six. This would have been the first calendar to use a leap



year, except that no-one took much notice of it and it was left to Julius Caesar to reintroduce the idea in 46BC.

Even 365.25 days is still an approximation, though: the current length of a year is more

Is your birthday on 29 February? If so, you'll only live to 25...

like 365.242374 days. So we have a rule that ignores leap years on a century year (1900, 2000, 2100 etc) unless the year is divisible by 400. So 2000 was a leap year but 2100 won't be, nor will 2200 or 2300. This gives us the more accurate average length of 365.2425 days in a year. The tiny error that is left would require an extra leap day every 8,000 years or so. But the length of the astronomical day and year are constantly changing due to subtle gravitational influences that can't be predicted to that level of accuracy, so we can't yet say for certain whether this will be needed. **LV**

Q KAREN ROSE, LEICESTER

## Why do starlings flock together at dusk?

**A** FOR PROTECTION IN numbers, and to keep warm and safe when roosting for the night. These huge, wheeling, chattering dark clouds of starlings are known as 'murmurations' and form in the evening as the birds return from foraging as much as 32km away.

In the UK, the autumn murmurations begin in about November, and the flocks grow larger as migrant birds from continental Europe arrive for the winter. Although most number between 5,000

and 50,000 birds, one Yorkshire murmuration used to boast 1.5 million. By flocking in such large numbers the birds are safer from sparrowhawks and peregrine falcons that try to pick out a meal from the fast-moving crowd.

Each bird tries to fly as close as possible to its neighbours and avoid being caught on the outside of the flock. It is this simple behaviour that creates the spectacular patterns we see in the sky. **SB**



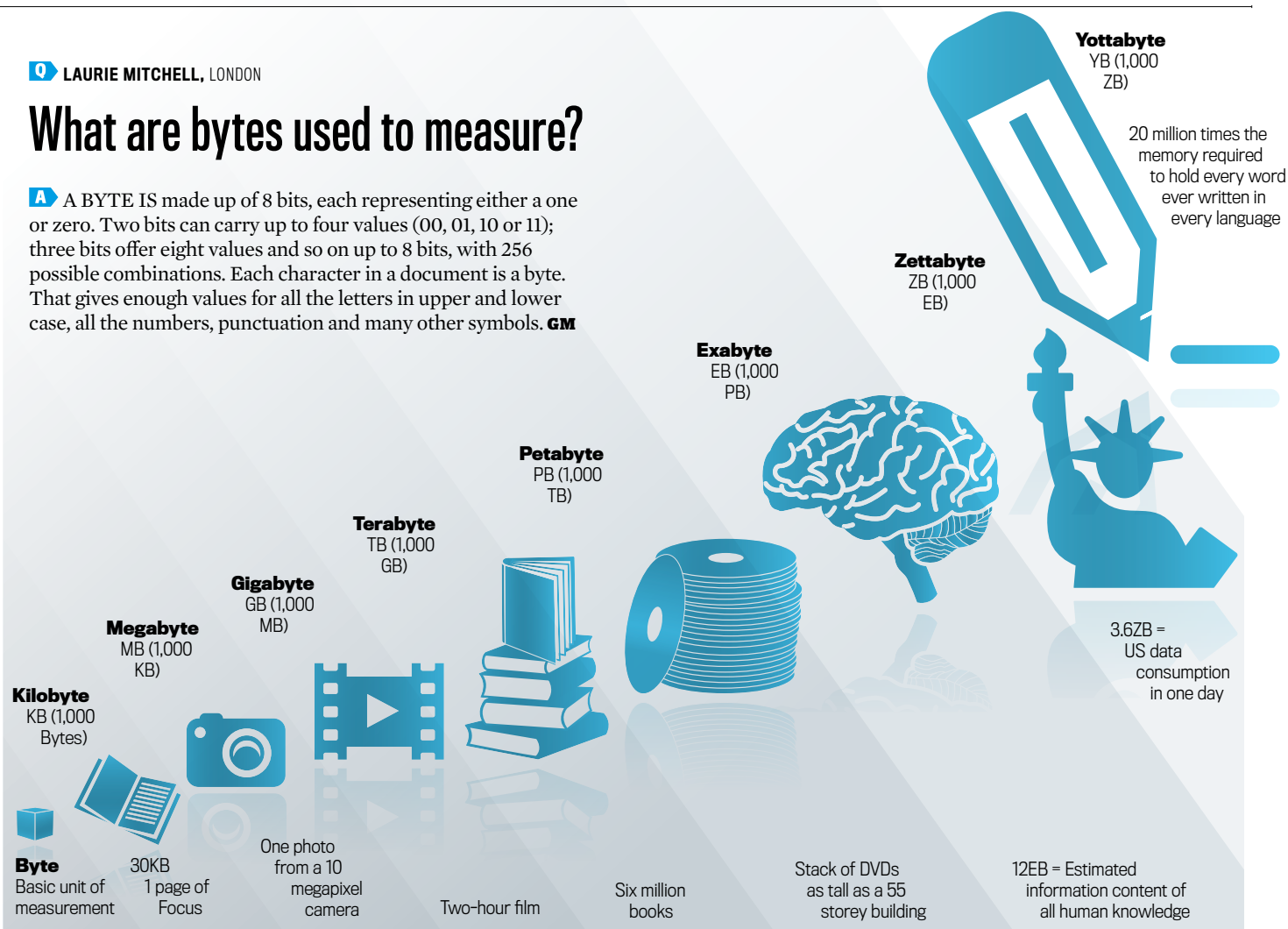
And they say three's a crowd...



0 LAURIE MITCHELL, LONDON

## What are bytes used to measure?

**A** A BYTE IS made up of 8 bits, each representing either a one or zero. Two bits can carry up to four values (00, 01, 10 or 11); three bits offer eight values and so on up to 8 bits, with 256 possible combinations. Each character in a document is a byte. That gives enough values for all the letters in upper and lower case, all the numbers, punctuation and many other symbols. **GM**



0 MATT ROGERS, GLASGOW

## How do we know what 'supermassive' black holes weigh?

**A** MANY, PERHAPS ALL galaxies are thought to harbour 'supermassive' black holes at their centres. Controversy surrounds their origin, but somehow a colossal amount of matter ended up crammed into a volume so small that it collapsed to form a black hole. Astronomers can estimate black holes' mass by searching for stars and other hot, glowing matter close to the centre of galaxies, and measuring their speed and distance from the centre. When these are plugged into formulas based on the law of gravity, they can show if the speeds are so high they can only be

explained if the objects are orbiting in the intense gravity of a giant black hole.

In the case of our own Milky Way, stars have been detected moving at astonishing speeds of several million kilometres per hour, on orbits just a few thousand times bigger than that of the Earth around the Sun. The law of gravity shows that this is only possible if the stars are orbiting an object with a compact mass around four million times that of the Sun – in other words, a supermassive black hole.

Astronomers have recently shown that sophisticated use of the same idea can reveal not just the mass of black holes, but also their rate of rotation. **RM**

**NEXT MONTH** Over 20 more of your questions answered



For even more answers to the most puzzling questions, see the Q&A archive at [www.sciencefocus.com/qanda](http://www.sciencefocus.com/qanda)



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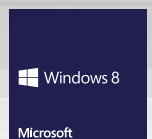
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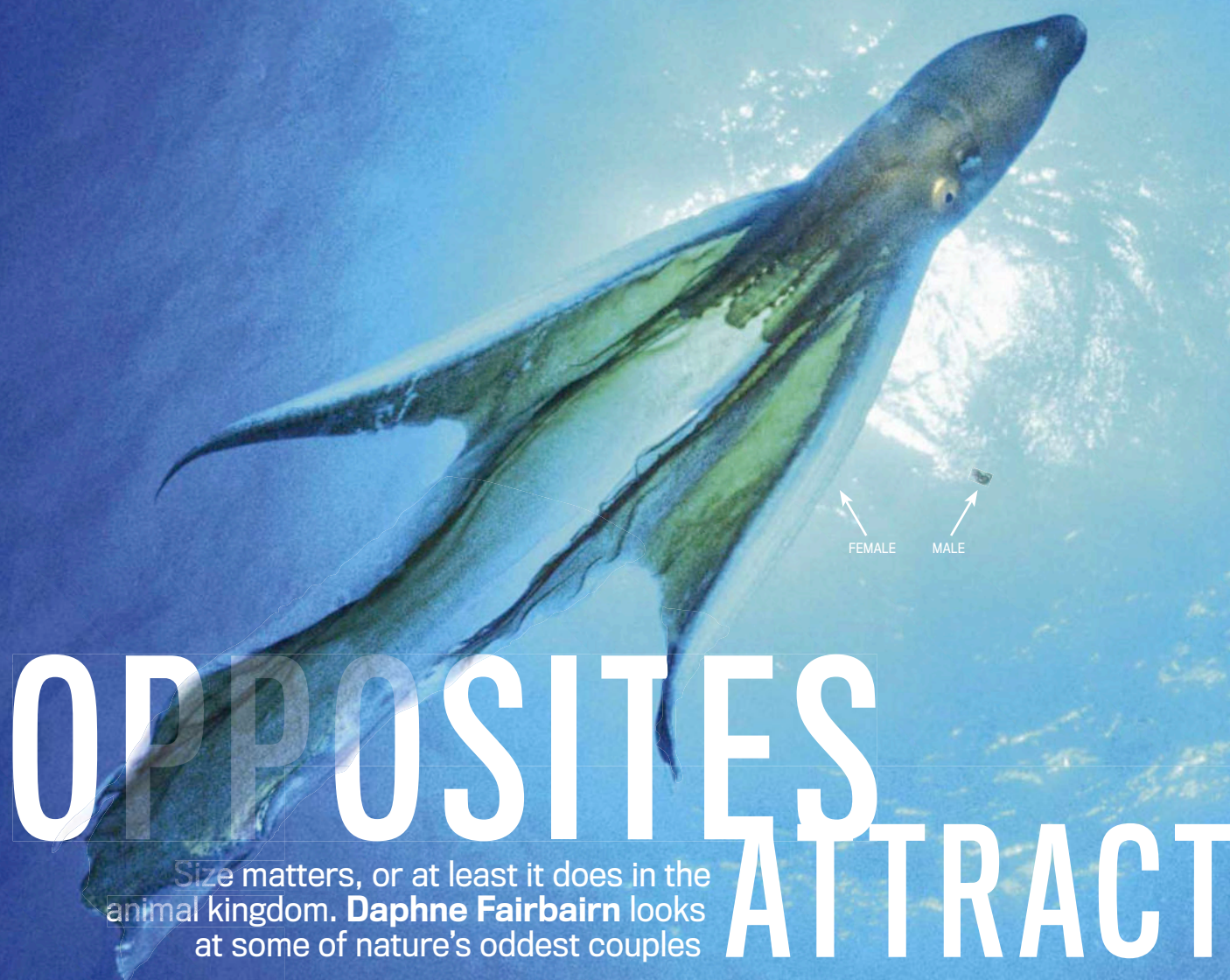
Prices correct at time of going to publishing (11th March 2013).

Images are for illustrative purposes only.

Monitors and desktop bundles are available separately.







# OPPOSITES ATTRACT

Size matters, or at least it does in the animal kingdom. **Daphne Fairbairn** looks at some of nature's oddest couples

## BLANKET OCTOPUS TREMOCTOPUS VIOLACEUS

THE MALES AND females of this graceful denizen of the open ocean are strikingly different to one another, more so than in any other octopus species. Females reach lengths of more than 2m and weigh up to 40,000 times more than males. The tiny males, which grow to no more than a few centimetres long, drift in the surface currents and sometimes catch rides on the bells of floating jellies as they search for a mate in the vast expanse of the open

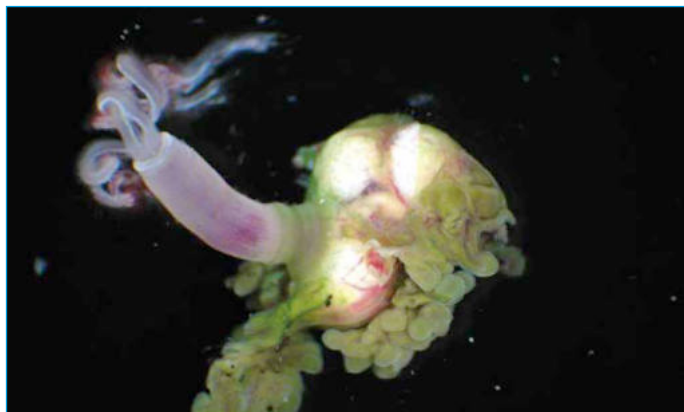
ocean. The males carry their sperm at the end of a long, specialised arm called the hectocotylus, and mating involves depositing this inside the female's mantle. Loss of the hectocotylus is fatal for males, so like the yellow garden spider, mating is their final act. Females, in contrast, often accumulate several hectocotyls before spawning hundreds of thousands of eggs, and it is thought that they need to indulge in multiple matings before they achieve full fertility.



## YELLOW GARDEN SPIDER ARGIOPE AURANTIA

THIS ORB-WEB spider is commonly found across much of the USA. The plump, brightly patterned females are about 2cm long (not counting legs) – more than five times longer and 50 times heavier than their diminutive mates. They spend their lives hanging in the centre of their webs, capturing prey and producing batches of hundreds of eggs, which they pack into globular silk cocoons. By contrast, the tiny males are thin and drab and abandon their webs as soon as they mature. They scramble through the vegetation in search of a mate, not eating and risking both predation and starvation. The few that do find a mate and succeed in mating will die in the act. After inserting the second of his two palps (his copulatory organs) the male's heart simply stops, leaving his lifeless body hanging from the copulatory duct. The giant females live on and often reproduce again, but for their dwarf partners, life ends with a single mating.



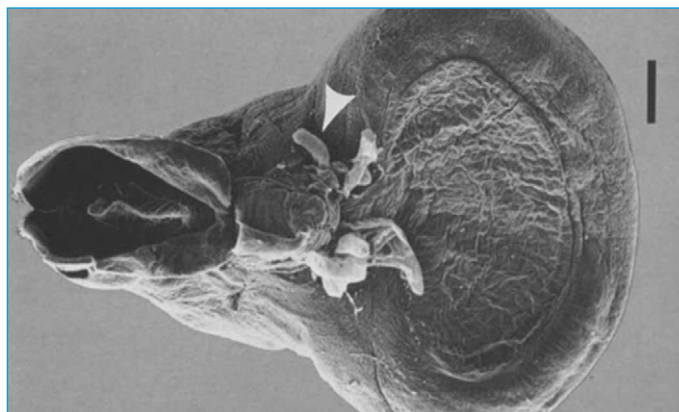


## ◀ BONE-EATING WORM *OSEDAX RUBIPLUMUS*

THIS TUBEWORM COLONISES the bones of whale carcasses that lie on the ocean floor. Female bone-eating worms have delicate red palps, thin transparent tubes about 4cm long, and branching, greenish roots that extend deep into the bone. The males, in contrast, are only about 0.1cm long and never develop this tubeworm morphology. They settle out of the plankton as larvae, attach themselves to the inner wall of a female's tube and immediately begin to make sperm. They never feed and simply convert the nutrients in their yolk, simultaneously digesting yolk and making sperm. A single male could not possibly produce enough sperm to fertilise all of a female's eggs, nor could he sustain himself long enough to do so. Females therefore collect new males continually and typically have tens to hundreds of males in their tubes at any one time.

## BURROWING BARNACLE *TRYPETESA LAMPAS* ▶

INSIDE THE CALCIUM-rich shells of large marine snails lurk these burrowing barnacles. Female *T. lampas* reach diameters of 1cm, which is large for a burrowing barnacle, and weigh up to 500 times more than their males. The females settle on shells as larvae, attach themselves and then gradually burrow into the shell wall as they grow, forming snug, protective burrows. Male larvae follow a very different path. They settle on the mantle sacs of the females and rapidly metamorphose into stripped-down dwarfs consisting of little more than a large testis and an enormous penis. To fertilise the female's eggs, the penis elongates and snakes its way into the mantle cavity, a journey many times the male's body length. The males never feed, fuelling all of their reproductive activity with the yolk provided to them in the egg. The giant females clearly need multiple mates to ensure full fertility with older, larger females typically hosting harems of 7-15 males.



## ◀ GIANT SEADEVIL *CERATIAS HOLBOELLII*

OUT OF ALL the vertebrates, the males and females of deep-sea anglerfish are the most different from each other. Females reach lengths of up to 1.3m and can be 500,000 times heavier than their mates. The tiny males never develop the distinctive anglerfish form. Once they reach adulthood, they abandon feeding and devote themselves to searching for a female in the gloomy depths. If successful, they latch onto the female's belly and metamorphose into permanently attached parasites, obtaining all their nutrition from the female's bloodstream. From then on, their only function is to fertilise the eggs of their giant mate.

**DAPHNE FAIRBAIRN** is professor of biology at the University of California, Riverside and author of *Odd Couples: Extraordinary Differences Between The Sexes In The Animal Kingdom*

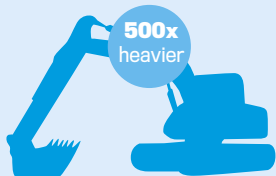
## IF THESE MALES WERE HUMAN, THEIR FEMALE COUNTERPARTS WOULD BE THE WEIGHT OF...



Average adult  
European male  
= 70.8 kg



**Yellow Garden Spider**  
3.5 tonnes  
= Large Ford Transit van



**Burrowing Barnacles**  
35 tonnes  
= Mechanical digger



**Blanket Octopus**  
2,832 tonnes  
= Saturn V rocket



**Bone-Eating Worm**  
14,160 tonnes  
= The Shard



**Giant Sea Devil**  
35,400 tonnes  
= Tanker ship



# A BEAUTIFUL

PHOTO: LABORATORY OF NEURO IMAGING UCLA/MARTINOS CENTER FOR BIOMEDICAL IMAGING MGH/HUMANCONNECTOMEPROJECT.ORG





# MIND

A multi-million dollar project is revealing how our brains work in unprecedented detail. **Rita Carter** gets her mind round the first results

**F**IRST CAME THE Human Genome Project - the catalogue of all the genes inside our cells. Now it's our brains that are being unravelled in the Human Connectome Project (HCP), a huge research

effort that's mapping connections and activity in our brains with greater precision than any other experiment.

Launched back in 2009, the first detailed HCP results are now being released. They come in the form of kaleidoscopic images showing bursts of electrical activity in neurones, hazy colour washes charting electrical flow through the cerebrum and weird bundles of swirling, neon-lit fibres resembling some exotic light-emitting insect.

As well as looking beautiful, these scans are providing intriguing insights into the inner workings of our minds.

Part of the HCP's work is to map the long-distance connections - the highways of nerve fibre - that make up the white matter inside our brains. These neural pathways are covered in white myelin, a fatty, protective covering. Overlooked in the past by neuroscientists, these links are proving to be very significant. "What's become apparent in the past few years is that the brain is this hugely connected system where activity in one area is propagated to others," says Assistant Professor Jack Van Horn at the University of California, Los Angeles (UCLA). He is part of the consortium that's mapping the white matter. "It's through this collective but spatially disparate pattern of activity that we generate our thoughts and actions."

Van Horn and his fellow neuroscientists have been tracing the long-distance links using 'diffusion spectral

↩  
A slice through the left hemisphere of the brain showing long-distance nerve fibres. Those in red are directed left-to-right in the brain, green fibres go from the front towards the back, while blue strands are from bottom to top.





→ imaging'. Here an MRI scanner is used to follow water as it naturally flows through the brain. "The water molecules diffuse more easily parallel to the fibres than across them," says Van Horn. So following these paths of least resistance reveals the routes the nerve fibres take. This kind of scan isn't new, but the HCP team, which also includes scientists at Harvard, has been super-charging its MRI scanner at Massachusetts General Hospital. "It's the Porsche of MRI scanners – it's high performance," says Van Horn. "That means the resolution is much higher."

Detail matters, because it's what makes us unique. Someone with relatively few pathways from their amygdala (the brain area that generates fear) to their prefrontal cortex (where fear is consciously experienced) is likely to be less nervous than someone whose neural wiring allows their forebrain to be deluged by subcortical doom alerts. A generous bandwidth from Wernicke's area – the bit of the brain that 'understands' spoken language – to Boca's area, where it is articulated, is likely to make an easy talker.

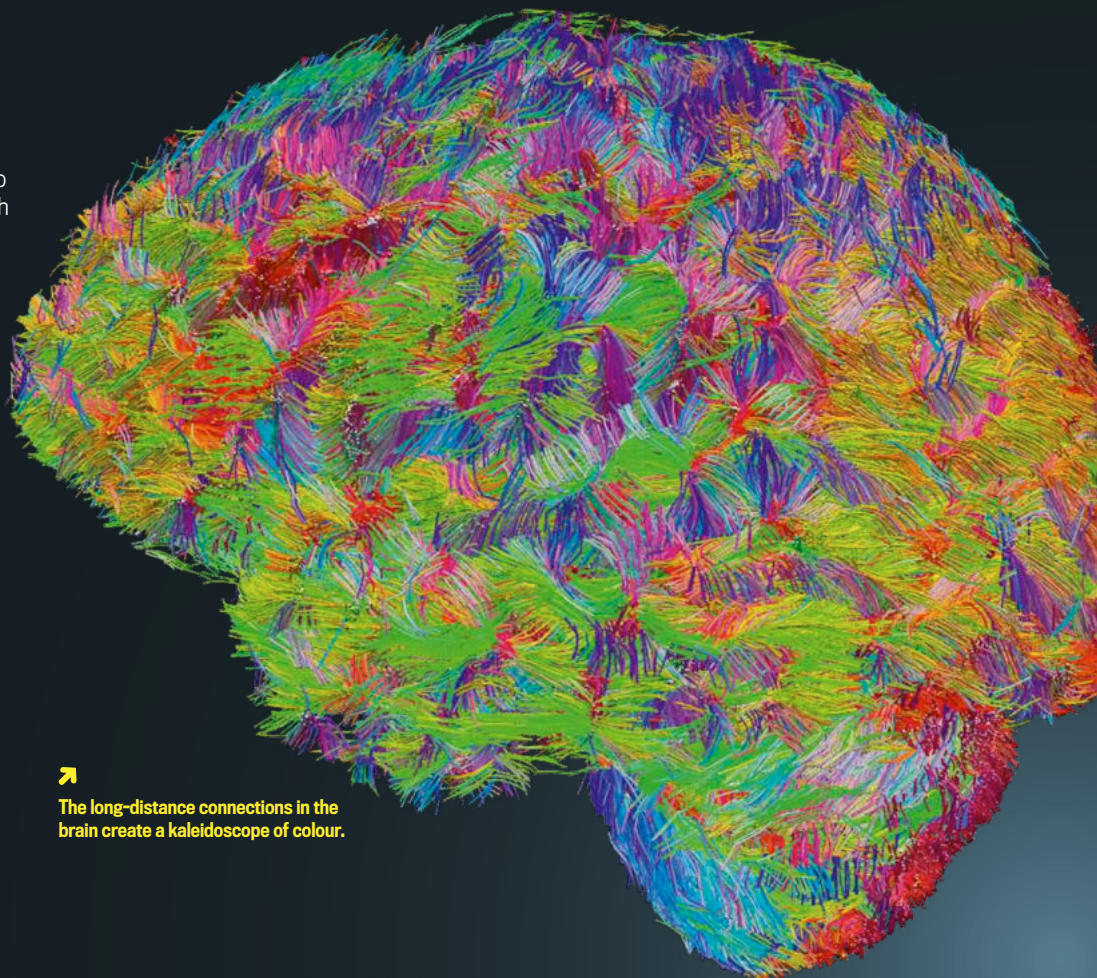
The UCLA consortium aims to release its first batch of data to fellow neuroscientists over the coming months so they can begin to untangle what's going on. By the end, they will have scanned the brains of 30-50 volunteers.

## NOW THERE'S A THOUGHT

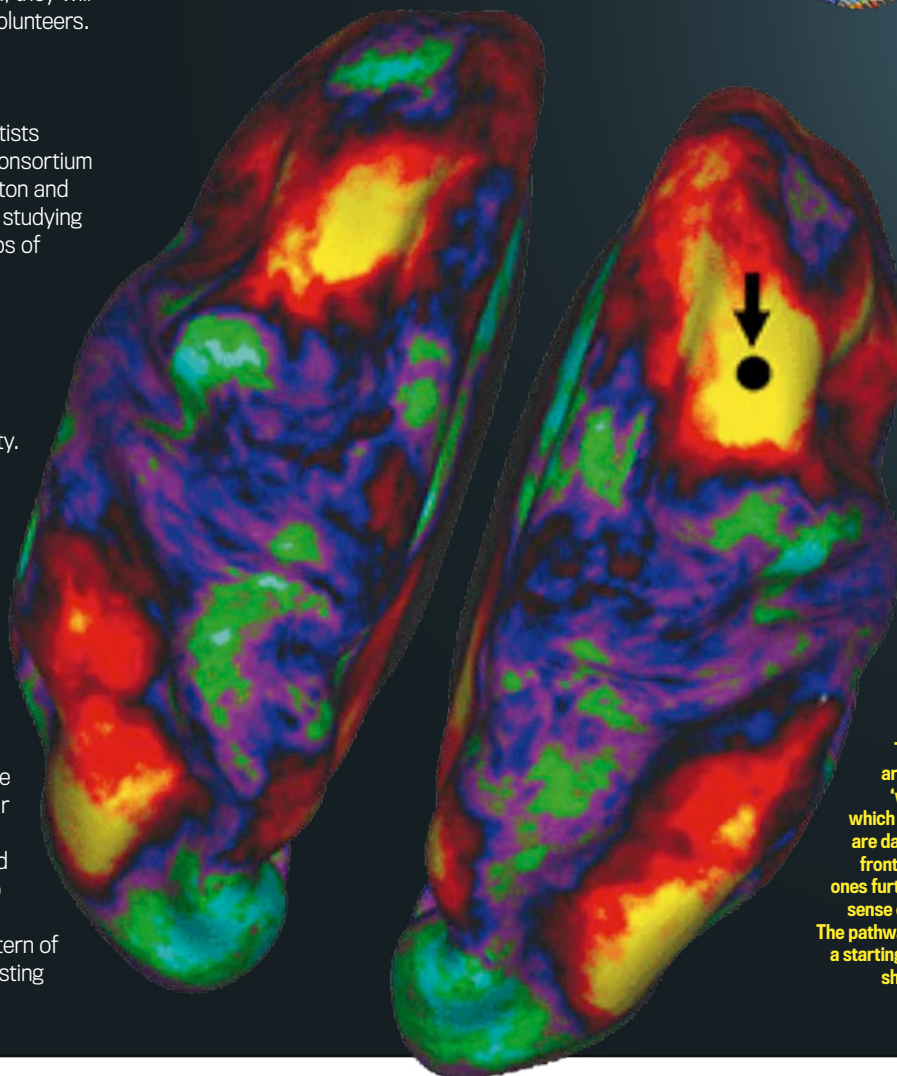
While the UCLA/Harvard neuroscientists are plotting the highways, another consortium made up of scientists from Washington and Minnesota universities (WU-Minn) is studying the local roads – the disparate groups of neurones that fire when someone's performing a specific task, such as listening to a story. And rather than following water, the WU-Minn team is plotting blood flow using an fMRI scanner, with areas of high flow revealing regions of high brain activity.

The daydreaming mind is also being analysed by the WU-Minn team in its scanners. Conventional brain imaging depends on giving people specific things to do, then seeing which bits of brain are activated in response. Recently, though, more attention has swung to the complex pattern of activity known as the Default Mode Network (DMN), or resting state, which occurs when people are relaxing. Scans of this show how our brains keep a running commentary on ourselves, ruminating on past and present events and 'anchoring' us to our lives.

"There's a very characteristic pattern of brain areas that participate in the resting



↗ The long-distance connections in the brain create a kaleidoscope of colour.



↖ The red and yellow areas are connected by neuronal 'wiring' (not shown here), which activates them when we are daydreaming. They include frontal 'thinking' modules and ones further back that create our sense of self in time and space. The pathways trace outwards from a starting point or 'seed location', shown here as a black dot.

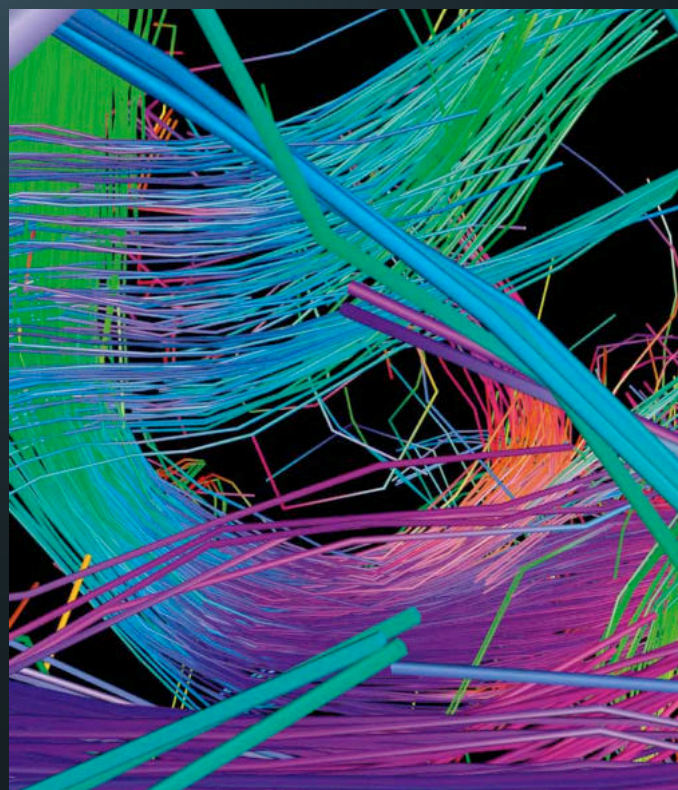


## "It's the Porsche of MRI scanners - it's high performance. That means much higher resolution"

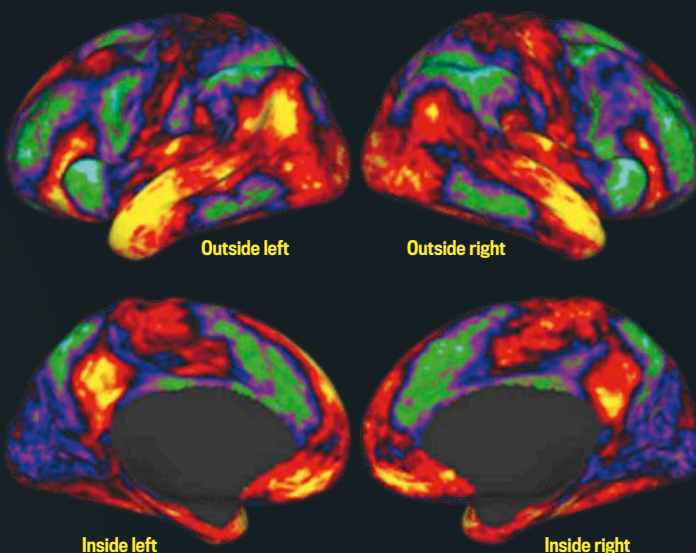
Assistant Professor Jack Van Horn at the University of California, Los Angeles

state," says Van Horn. "This is probably the biggest, most concerted effort dedicated to gathering data on this and looking at the genetic components of these patterns." The WU-Minn team has just released its first batch of data - the brain scans of 68 volunteers - along with details of these volunteers' personalities and cognitive capabilities. Its final target is 1,200 brains scanned.

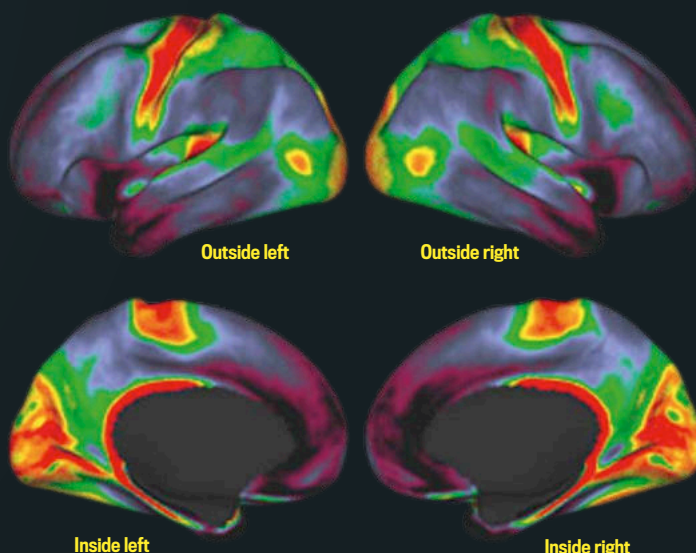
The end result of this five-year project, bankrolled to the tune of \$40 million by the National Institutes of Health in the US, will be a multi-layered brain map showing how a person's genes, behaviour, and neural 'wiring' relate to one another. It'll not only give the clearest picture yet of how the healthy mind works but also help researchers spot what goes wrong in brain disorders. "This research will provide the baseline we can build upon and that baseline is fundamental," says Van Horn. ■



The interconnected yellow and red areas activate when a person listens to a story. They include Broca's and Wernicke's language areas on the left side (top row, left). The equivalent areas on the right process tone and emotional impact.



Myelin is a fatty covering that protects the nerve fibres and speeds electrical impulses like insulation around a wire. Regions of the brain that perform different tasks have different amounts of myelin. These dark areas have thin sheathing while the red and yellow areas - mainly regions concerned with sensation - have more.



The fine structure of white matter fibres is clear - showing just how sensitive the diffusion spectral imaging (DSI) technique is.

RITA CARTER is a neuroscience writer and author of *Mapping The Mind*

### Find out more



Listen to Radio 4 programme *Wiring The Brain* on the Human Connectome Project. See <http://tinyurl.com/cy6nqvj>



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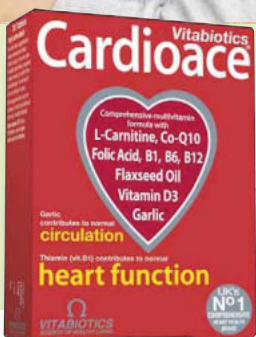
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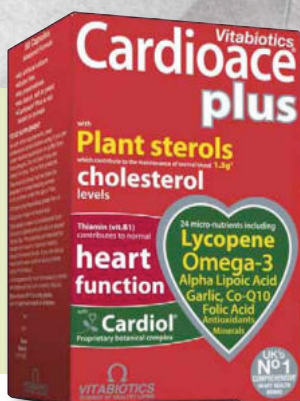
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- ♥ Maintain your body weight within the normal range for your height.

Originally developed with


*Prof. A. H. Beckett†*  
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(1920-2010)  
Professor Emeritus,  
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Vitamin supplements may benefit those with nutritionally inadequate diets. † Professor Beckett is not cited in the capacity of a health professional, but as a product inventor and former Chairman of Vitabiotics.

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## THE FUTURE OF GADGETS

# TECHHUB

### THIS MONTH

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p81

**JUST LANDED**  
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p82

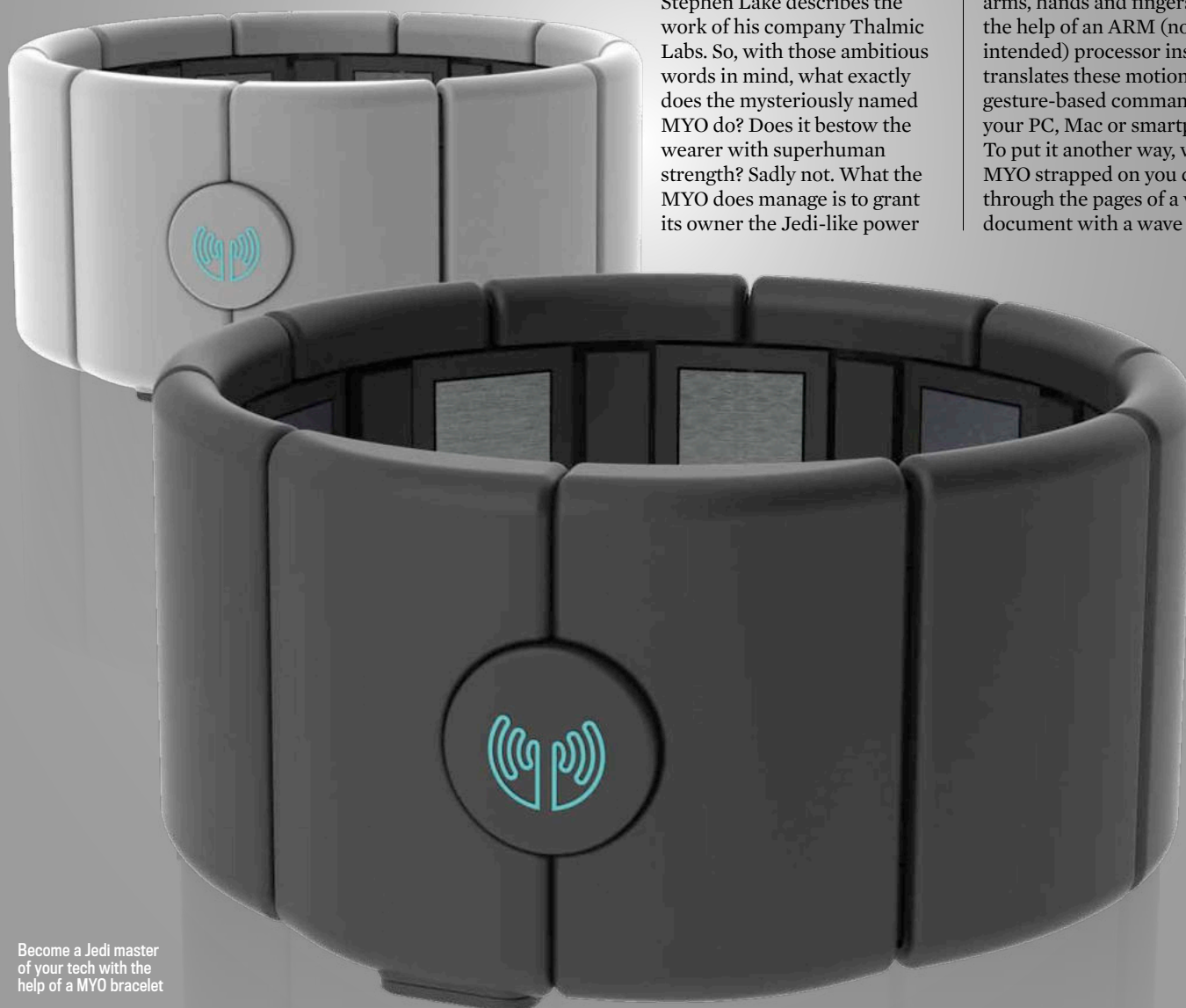
**ULTIMATE TEST**  
Next-generation PCs  
p85

EDITED BY **DANIEL BENNETT**

### ON THE HORIZON

## MYO

GETMYO.COM, \$149 (£98)



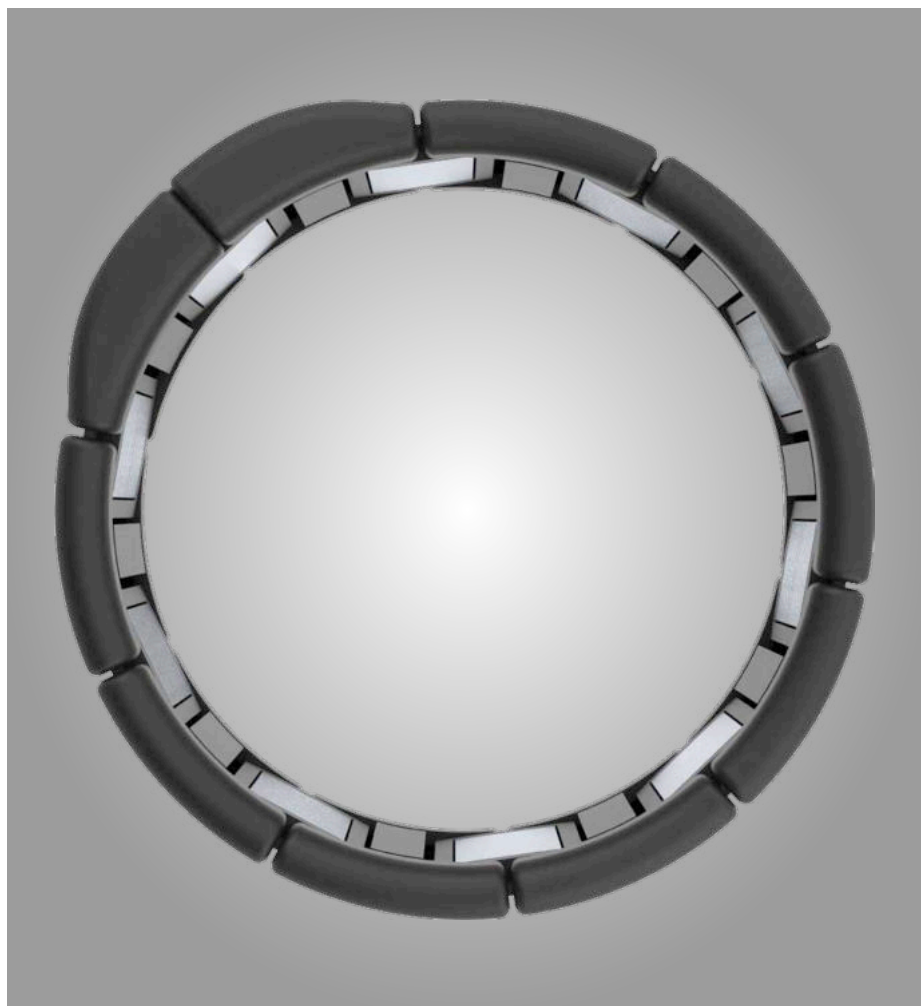
“WE WANT TO use technology to enhance our abilities as humans – in short, giving us ‘superpowers.’” That’s how MYO’s creator Stephen Lake describes the work of his company Thalmic Labs. So, with those ambitious words in mind, what exactly does the mysteriously named MYO do? Does it bestow the wearer with superhuman strength? Sadly not. What the MYO does manage is to grant its owner the Jedi-like power

to move objects with the flick of a wrist, well, virtually speaking at least.

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Become a Jedi master of your tech with the help of a MYO bracelet





Looking like a piece of jewellery that might be worn on the set of a *TRON* film, MYO measures electrical activity in your wrist muscles to discern what position your fingers are in. You'll then have full, sci-fi control over your gadgets



hand, or play a shooting game by sticking out your finger and pointing at the screen.

If you own a Kinect, then this might sound familiar. Indeed, you can even buy TVs that let you change channel or the volume by waving your hands about. Unlike the MYO though, these use a camera to tell the telly or the games console what your arms are doing. This means you can't ever take your Kinect out of the living room, and that you need at least 4m between you and the camera so it can see your whole upper body.

Since the MYO monitors your muscles directly and sends its output via Bluetooth, you can use it anywhere with any device. We've seen prototypes used to fly remote-control helicopters and play the likes of *Battlefield 3* on a PC. Before long, with the help of some software, developers say they'll have it working in harmony with the latest generation of smartphones.

Thalmic Labs isn't alone in thinking that gesture commands need to evolve beyond

Kinect. Regular *Focus* readers might recall a prototype created by Microsoft called Digits, which used a wrist-mounted camera to replicate your hand movements on a computer. Meanwhile, a company called Leap Motion is working on a product that uses infrared cameras to detect the movement of PC and Mac users.

All of the above rely on camera technology, and this is where MYO will have the real edge. By going directly to the source – ie your muscles – it has the potential to be more accurate and more versatile than the competition. Only time will tell, of course, but in a world where the minerals that make touchscreens are become more scarce by the minute, it seems as though gesture control might be the chief way we control our technology in the future.

**DANIEL BENNETT** is the reviews editor of *Focus* magazine

## TECHOMETER

### WHAT'S HOT

#### BLACKBERRY

The dinosaur of smartphones looked like it might be heading towards extinction in the last few years. But its latest device, the Z10, is bursting with enough innovative tech to turn around the company's ailing fortunes. For example, if you're caught blinking in a photo, the Z10's camera isolates your face and rewinds to two seconds before the picture was taken – in other words, when your eyes were open, giving you the perfect shot.

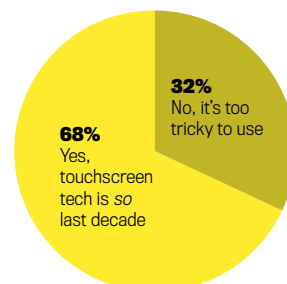
### WHAT'S NOT

#### MOBILE PHONE BILLS

A recent study by the site billmonitor.com analysed over 2 million of its users' phone bills to find that most were using under a quarter of their data allowances. Most people had bought bigger data plans than necessary, fearful of running into costly surcharges. Since everything from using Facebook to watching a video eats into your data allowance, it suggests a rethink of how mobile phone companies charge for data is in order.

### READER POLL

Will gesture control replace touchscreens?







## EARLY ADOPTER BILL THOMPSON

# Libraries nurture the digital age

**L**IBRARIES – school libraries, town libraries, college and university libraries – matter to me and to many other people, and not just because the books are generally free to read. They offer a lot more than just books. Today's libraries are information centres and internet access points for a wide community, with help and support on offer for using many online services.

At the moment local councils fund libraries and the money available to them has been reduced as part of wider cuts in government spending, while some libraries are being handed over to voluntary groups or charities. However, a recent report by Arts Council England on "the Library of the Future" offers hope, by placing libraries in a broader context as key parts of the information society rather than just rooms full of books or public cybercafés. We find ourselves at a point in time where the library will either become extinct or adapt and evolve into something fitter for the modern age.

For me, libraries are important because up to now they've delivered literacy to anyone willing to pick up a library card. But to my mind, using a

mouse to control a cursor is as important as learning to understand letters on a page. Besides, it's likely that our screen-based culture is changing the nature of reading itself in subtle ways.

Libraries can provide a bridge between these old book-based forms of literacy and the newer computer-based proficiencies. The point of having a place to learn



'digital skills' is not to replace physical spaces with online ones or physical books with electronic editions, it's to allow the two spaces to intersect to the point where there is no need to distinguish between them.

Tomorrow's libraries will have to offer access to the shared space of the network. It's more complicated, because it requires more than shelves, seats and light to read by, but it's no less important.

A good example is the DOK Library Concept

Center in Delft in the Netherlands, which combines bookshelves with Spotify-enabled listening stations, Xbox consoles and a multi-touch surface screen that interacts with readers' RFID tagged library cards. RFID is short for Radio Frequency Identification and it works like the wireless equivalent of a barcode scanner.

Meanwhile, other pioneering libraries are realising that coding, the ability to write computer language, is incredibly valuable. Woking Library in Surrey already has a coding club, while the delightfully named Coder Dojo Cymru, a computer coding club for youngsters aged 8-14, meets on Saturday mornings at Caernarfon library. Outside of the libraries, projects like the Young Rewired State are satisfying a growing hunger among young developers under 18 who want to learn coding as it isn't being taught in their schools.

Libraries can become the ideal home for things like this, teaching new skills that students young and old haven't been able to find anywhere else. Just like they've always done.

Bill Thompson contributes to [news.bbc.co.uk](http://news.bbc.co.uk) and the BBC World Service

## COMING SOON

### 3 MONTHS

#### NEW NEXUS 7

Google's next tablet will be with us by summer. Of course it'll be lighter, thinner and more powerful, but we're really excited to see what innovations the search giant has in store. Rumours suggest it might cost under £200. [Google.co.uk/nexus](http://Google.co.uk/nexus)



**+ HTC First** HTC has partnered with Facebook to come up with an Android-based operating system revolving entirely around the social network. This will no doubt be the Marmite of the tech world. [HTC.com](http://HTC.com)

**+ Razer Edge** A tablet designed for gamers, the Edge can handle all the latest blockbusters a console can. [razerzone.com](http://razerzone.com)

### 6 MONTHS

#### PLAYSTATION 4

Good boys and girls will be hoping to find Sony's new games console under their trees this Christmas. With the ability to share replays over Facebook at the press of a button and live streams of your game with friends, this will be the most social games console yet. [PlayStation.com](http://PlayStation.com)



**+ Intel TV** Better known for its microchips, Intel is looking to enter the world of streaming telly before the year's out. [Intel.com](http://Intel.com)

**+ Vuzix M100 smart glasses** This Bluetooth headset presents your phone's display on a tiny screen aimed at your right eye, so you can see maps, call info and text messages without having to get your phone out of your pocket. [vuzix.com](http://vuzix.com)

### 9 MONTHS

#### Xi3 PISTON

This tiny PC aims to pack more power than the latest consoles and fit in the palm of your hand (just about). This ambitious promise has been given credence since Xi3 has partnered with Valve, the creator of *Half-Life*, to bring PC gaming into the living room. [Xi3.com](http://Xi3.com)



**+ Samsung Youm** The Korean tech company has just launched the Galaxy S4, and its next device is reported to be the Youm – a flexible, paper-thin phone. [Samsung.com](http://Samsung.com)

**+ Google Glass** Google's future vision for internet-connected glasses has been spotted being tested on the New York subway. It could be utterly amazing or utterly annoying. We can't wait to find out which. [Google.com/glass](http://Google.com/glass)

## TELL US WHAT YOU THINK!

Do you think libraries should be a gateway to our networked future? Tell us what you think by emailing us at [reply@sciencefocus.com](mailto:reply@sciencefocus.com)



JUST LANDED

# BEYOND BLU-RAY

Jamie Carter goes goggle-eyed as he tests the RedRay 4k Cinema Player - the first Ultra-HD media player



REDRAY, £950  
WWW.RED.COM

## What is Ultra HD?

It's a new type of TV and video that contains four times more detail than current HDTVs can show. There are Ultra HD sets already on sale – costing an eye-watering £22,000 – but it should become standard within five years. There is one major hold-up though. While HDTVs first played HD content on Blu-ray discs, there's no equivalent for Ultra HD yet.

## What's wrong with Blu-ray?

It may not seem long since we moved from standard definition to HD, but resolutions don't tend to hang around for very long in the world of film-making. HD cameras can film 1,920x1,080 pixels, which equates to about two megapixels, while Ultra HD's 3,840x2,160 resolution achieves four megapixels – hence the '4k' nickname.

Images look far more detailed and more immersive, and both of those advantages make 3D look so much more

convincing, too. Ultra HD might seem like overkill to some, but try telling that to anyone used to looking up close at the iPad 4's Retina screen, which is already higher-than-HD despite having a tiny 10-inch display.

The movie industry has moved on, too, with Ultra HD cameras now routinely used by the likes of Peter Jackson and James Cameron. Even old classics like *Schindler's List* are now being re-scanned to Ultra HD ready for playback by the RedRay.

## Is there a 'red ray' in the RedRay?

No. Blu-ray is named after the blue laser that scans a disc, whereas the 'red' in RedRay comes from the manufacturer, RED. It's a rather ironic name because RedRay actually abandons the idea of a disc altogether in favour of data files. It's connected to the internet and downloads Ultra HD films from a central server to store on its 1TB hard disk

drive. It then connects to a TV using a HDMI cable, as normal. There are other possibilities, too, because the RedRay can read Ultra HD data from both normal USB sticks and SD cards used by cameras.

## Will my broadband cope?

Ultra HD content has to be compressed from the 10GB per second captured by a RED camera to just 2.5MB per second to send over the internet – that's a 500:1 shrink – but remarkably the images remain sparkling. The detail is truly awesome.

You might have to plan ahead, though, since Ultra HD files for the RedRay will still be relatively large. Downloading or streaming one hour of HD from somewhere like Lovefilm Instant or Netflix currently uses between 1GB and 2.3GB of data, but an hour of Ultra HD uses up around 9GB. So it's best to check your internet service provider's

data plan, and your transfer speed before investing.

## Should I buy one?

If you've already bought – or are about to invest in – an Ultra HD TV, then you're a very wealthy person (or, at least, you were). You've also probably never seen anything in 'pure' Ultra HD yet because most Ultra HD TVs merely upscale Blu-ray discs, so a RedRay is an absolute no-brainer – especially since its price tag of £950 is a fraction of the cost of an Ultra HD TV.

However, for the rest of us, RedRay is probably a little too early. It'll be interesting to see if the Blu-ray Disc Association approves a disc format for Ultra HD, though that might not matter in the long run. Netflix and Samsung are already experimenting with Ultra HD downloads, so perhaps the era of the shiny disc really is dead.

**JAMIE CARTER** is the editor of *Home Cinema Digest*





# APPLIANCES OF SCIENCE

## 1 SQUARE UP

It was about time someone had a go at reinventing the TV. This set is made from one large sheet of glass that can either be mounted on a wall, stood upright with a near-invisible stand or (if you're truly brave), leaned against a wall. As well as Wi-Fi streaming and 3D playback, it comes with an Ambilight, which matches the colours from the film you're watching and throws them out on the wall behind to set the mood. **Philips DesignLine TV** [Philips.co.uk](http://Philips.co.uk), price TBC

## 2 SIMPLE SOUNDS

This brick-sized wireless travel speaker pumps out music from your smartphone without using Wi-Fi, Bluetooth or NFC trickery to do so. You simply plop your phone on the device, press play and sound pours out of the Touch Speaker. Instead of relying on complex wireless tech to manage this, it uses a small mic to pick up your phone's own sound output and amplify it. **thumbsUp! Touch Speaker** [thumbsupuk.com](http://thumbsupuk.com), £29.99

## 3 PLUGGED IN

Your house's wiring can be used to carry more than just electricity. Plug this HD JuiceBox into your set-top box and the nearest power socket, and it'll ferry the TV signal through your home's power cables to another socket that has a second JuiceBox plugged in. Connect this to a TV, and you can carry a signal across rooms and through floors. It's great if you only have one TV aerial socket in your house. **HD JuiceBox** [justhdtv.co.uk](http://justhdtv.co.uk), £307.50

## 4 SIZE MATTERS

Any photographer will tell you that it's not the number of megapixels that matters most on a camera. So it's good news that at least one phone manufacturer is paying attention. The HTC One opts out of the megapixel arms race to focus on capturing more light. It manages this by making each individual pixel bigger. The end result is a four-megapixel camera that's optimised for snapping real-world (badly lit) photos. **HTC One** [htc.com](http://htc.com), TBC

## 5 GREEN TREES

Going green needn't involve scratchy hemp jumpers and an 18 varieties bin that takes up half your kitchen. You can save the planet and look good. Take this elegant solar-powered, wireless charger. The Electree comes in parts so you can create your own arrangement of branches that gather light. It stores the electricity it gathers in its battery and delivers it to a phone or tablet via USB or wireless induction charging. **Electree** [electree.fr](http://electree.fr), £294.93

## 6 CUT-PRICE COMP

At £28 the Raspberry Pi – a credit-card sized computer – isn't exactly expensive. In fact, we've owned pricier calculators. But now, its creators have released a budget £20 version, the Model A. This stripped-down alternative has no Ethernet port, one less USB port and half the RAM (256MB). Crucially this means it draws less power so it's better suited to DIY projects where the Pi needs to run off a battery – like in a small robot, for example. **Raspberry Pi Model A** [raspberrypi.org](http://raspberrypi.org), £20

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ULTIMATE TEST

# SURVIVAL OF THE FITTEST

Are desktop computers a thing of the past? No, says **David Bayon**, they're more innovative and exciting than ever. He tests four of the best →



SO MANY HOMES now have a slim, lightweight laptop, a tablet on the coffee table and a games console under the TV that it's no surprise the trusty desktop PC is in trouble. Global sales keep tumbling – down 6 per cent last year – but rather than roll over and take it, this threat has spurred desktop manufacturers into action. The big black boxes of old are on the way out, replaced by tiny powerhouses, giant touchscreen slates and innovative PCs that take on the consoles at their own game.

You can thank several factors for this. The oft-maligned Windows 8 has forced manufacturers to take touchscreens seriously, to the point where they're now pretty much everywhere. Intel's processors are faster than ever, while shrinking to ever more efficient dimensions. And then there's the competition: the PC is just another gadget now, and we want it to be as simple and stylish as an iPad. These four desktops are only too happy to oblige... →

PHOTO: THESECRESTUDIO.NET

## BEST FOR SIZE



### INTEL NUC

[www.intel.co.uk](http://www.intel.co.uk), from £230

➔ IT'S UNUSUAL TO see Intel in the PC game, but then this is an unusual PC. The NUC – it stands for Next Unit of Computing – is Intel's way of showing off just how tiny and efficient its latest chips are. Think you've seen small PCs before? Pile up seven or eight drinks coasters and that's how small the NUC is, yet within those diminutive dimensions lies the power of a full desktop. With an embedded Core i3 processor, it's capable of playing HD video and even a bit of gaming if you keep the settings low, and the whole thing runs pretty much silently. It comes in two flavours: both have three USB ports and an HDMI

output, but the maroon edition offers a Thunderbolt port for extra storage, while black comes with Ethernet and a second HDMI port.

There are two catches. The first is that you have to buy a hard disk and RAM separately. A screwdriver will have it open in seconds, but if the thought of installation puts you off, Quietpc.co.uk sells a modified UltraNUC for £449. The second is that it uses a special mSATA hard disk, and they're not cheap – around £150 for a 256GB drive. Still, this tiny powerhouse could be an under-the-TV media centre, a home server or even a take-anywhere second PC.

## BEST FOR CREATIVE WORK



### APPLE IMAC 27

[www.apple.com/uk](http://www.apple.com/uk), from £1,499

AS WELL AS thinning its consumer desktop down to an astonishing 5mm at the edges, Apple made a curious addition to the latest iMac. The optional Fusion Drive – tagged 'high capacity meets high performance' – is an SSD and hard disk combo, linked together by some clever software. Your most frequently used applications go on the ultrafast SSD, with less critical stuff on the slower but larger hard disk, and it shuffles files from one to the other automatically as you change your working habits. The result is a personalised system that boots and opens applications more quickly as it gets to know you.

Add that to the latest Intel processors and gaming-capable Nvidia graphics, along with fast Thunderbolt ports that let you edit video directly on huge external storage arrays, and it's no surprise that you'll find iMacs on art, design and media production desks all across the land.

Despite a string of contenders for its crown, the iMac remains the perfect blend of superb software and processing power. Its screen is unmatched in its colour accuracy and image quality, and it has looks that regularly get it into Hollywood blockbusters. Always on the desks of the good guys, of course.

### THE NEXT GENERATION

If the hardware line-up above isn't forward-thinking enough for you, here are some even more innovative PC designs coming your way over the next year or 10...

#### MISEETX

**WHEN?** On sale in the US

This tiny PC does it all. A laser projector at the front throws out a virtual keyboard and mousepad onto any surface, and a built-in camera tracks your fingers as you hit the keys. On the other side is a projector, which beams Windows onto any wall or screen.



#### LENOVO IDEACENTRE HORIZON TABLE PC

**WHEN?** Summer 2013

Who wouldn't want to play air hockey on a touchscreen table? Or go fishing with joysticks? The 27-inch Horizon is due soon in the US for close to \$2,000, but we're waiting for the 39-inch prototype to become a reality in our local pub.





## BEST FOR GAMING



## ALIENWARE X51

www.alienware.co.uk, from £539

HIGH-END GAMING PCs tend to be the size of breeze blocks, but not the Alienware X51: it's been shrunk to Xbox 360-proportions to compete with the consoles in your living room. This crash diet means it can't quite pack the huge graphics cards of beefier rigs, but the X51 still has the smarts to run the latest games with better visuals than current consoles. The X51 ran *Battlefield 3* at all but the highest settings with little fuss, and unlike consoles you can run everything at 1080p if you wish.

With a HDMI port at the back, it's easily connected to an HD telly – there's even an automated setup that optimises the display

for your TV's dimensions. And with eight USB ports, you can hook up a keyboard and mouse alongside several gamepads. The built-in solid state hard drive also makes for rapid loading times and incredibly fast start-up.

The only area in which it doesn't trump home games consoles is in price. But then you get so much more for your money, because although it's tuned for gaming, the Alienware can easily moonlight as a home media centre – its 2TB hard drive has room to store thousands of films and songs. Or it can be a simple office computer handling your work needs. In short, a great PC option for gamers.

## BEST FOR FLEXIBILITY



## SONY VAIO TAP 20

www.sony.co.uk, £999

THE BEST THING about tablets is being able to use them anywhere, right? Sony thinks so too, so obviously it makes sense to apply that logic to an all-in-one PC. Yes, the VAIO Tap 20 is basically a vast 20-inch Windows 8 tablet. This touchscreen monster comes with a mouse and keyboard for all the usual desktop PC jobs, and an Intel Core i5 processor to handle work and even a bit of play, but when the need for portability arises it can use its secret weapon: a lithium-ion battery.

Alright, it's not going to replace your iPad just yet – it weighs over 5kg and can barely manage two hours of web browsing on a single

charge – but it's not really meant for that kind of tablet portability. Instead it gives you the best of both worlds: it's a normal desktop PC, just one that can be picked up and moved from room to room. Plus, the kickstand folds flush into the back so you can lie the Tap 20 flat on a table and let the family prod it from all sides with up to 10 fingers at once – the kids will love using apps like Fresh Paint on the big touchscreen.

It's not cheap, but there's nothing else quite like it around – at the moment, anyway.

**DAVID BAYON is a PC expert and technology journalist**

## PANASONIC 20-INCH 4K TABLET

WHEN? TBC

The Ultra HD 4K format has barely made it into TVs (see p82), yet here it is gracing a 20-inch all-in-one PC. There's no guarantee it'll ever pass the concept stage, but if it does, 4K will probably be the price as well as the resolution.



## PAPERTAB

WHEN? TBC

A paper-thin, flexible device that's meant to emulate the feel of paper: the user would have several, with an app running on each, and tap them together to transfer files. It's a crazy idea, but the thought of rolling up our PC for the commute definitely appeals.



## SPACETOP

WHEN? Within 10 years

Shown at TED 2013, SpaceTop has a transparent LED screen and a series of cameras that track your hand movements behind it, so you can manipulate 3D objects on-screen.



# THE ORIGIN OF THE MOON

**BY GILES SPARROW**

Giant impacts, material flung off the Earth and captured rock have all been offered as explanations for our satellite

**A**

**F**TER THE SUN, Earth's Moon is the most obvious object in our skies – an ever-changing but reassuringly permanent presence in the heavens. Yet the origins of our satellite were a mystery for astronomers until recently, and may still not be entirely resolved.

Many ancient cultures from around the world had their own legends about the origin of the Moon. Most were linked to a mythological understanding of the cosmos that considered the Sun, Moon and stars as avatars of the gods. As far as we know, the ancient Greeks were the first to treat the Moon as a physical object in space, but the idea of the heavens as a celestial clockwork, maintained by divine power throughout eternity, went largely unchallenged into late medieval times.

The first detailed theory to explain the origins of Earth and the Solar System in scientific terms was the 'nebular hypothesis' proposed by the Swedish philosopher Immanuel Swedenborg in 1735, and developed by the French mathematician

Pierre-Simon Laplace in 1796. In this model, interstellar nebulae – clouds of gas and dust between the stars – collapse and coalesce to form the stars and planets that surround them. The worlds of the Solar System therefore grew in stages from the bottom up, and collisions between them released enough heat to melt and separate them into layers of different densities. Laplace's theory has since turned out to be substantially correct, although it spent much of the 19th and early 20th Centuries out of favour.

For Laplace, the most obvious explanation for the Moon was that it must have formed alongside Earth (a process known as binary accretion) and been a constant companion since the earliest days of our planet's history. But even Laplace could see that the Moon's huge size presented a problem. With a diameter more than a quarter of Earth's own, it is by far the largest satellite compared to its planet in the Solar System. This seemed to demand that Earth's formation left behind an unfeasibly large amount of excess material.

Ironically, Laplace's theory fell temporarily from grace – replaced by a cold-formation theory – before the problem of the Moon's diameter could undermine it. This left the way open for other theories. Perhaps the most promising alternative was put forward by astronomer and mathematician George Darwin, son of the great naturalist Charles, in 1879.

Darwin's theory was inspired by the then-recent discoveries of the Moon's outwardly spiralling orbit and the gradual slowing of the Earth's rotation, both linked to tidal forces between the two. He argued that the young, semi-molten Earth might have spun so rapidly that the resulting tidal bulge around its equator became unstable, flinging off large amounts of material that then coalesced to form the Moon. Four years later, geologist Osmond Fisher added colour to the theory with his suggestion that the enormous Pacific Ocean basin could be the scar left behind by this separation.

Many doubted that Earth's rotation could have slowed down quite so dramatically throughout its





The giant impact theory holds that an object the size of Mars collided with the early Earth, giving birth to the Moon

## **> IN A NUTSHELL**

Once, the Sun, Moon and planets were thought to be avatars of the gods cavorting in the night sky. Our knowledge of the Solar System's make-up has come a long way since then - but the history of the Moon remained a mystery until very recently.



→ history; others pointed out that, big though it is, the Pacific basin has only a fraction of the volume of the Moon. But the fatal flaw in Darwin's theory emerged from an improved understanding of fluid dynamics. In 1930, geophysicist Harold Jeffreys showed that the enormous bulge that would have developed around Earth's equator would also have acted as a natural brake. This would have prevented our planet reaching the extreme spin speeds needed to fling off the Moon. Variants of Darwin's fission theory remained vague possibilities

until the 1960s, but shortly after World War II they were faced with competition on three fronts.

In the early 1950s, chemist Harold Urey and astronomer Horst Gerstenkorn revived the capture theory first proposed by Thomas Jefferson Jackson See in 1909. In this model, the Moon evolved elsewhere in the Solar System, before being captured into a close orbit around Earth. Some astronomers argued that the relative speeds of the two bodies during such an encounter would have been too large for gravity to overcome

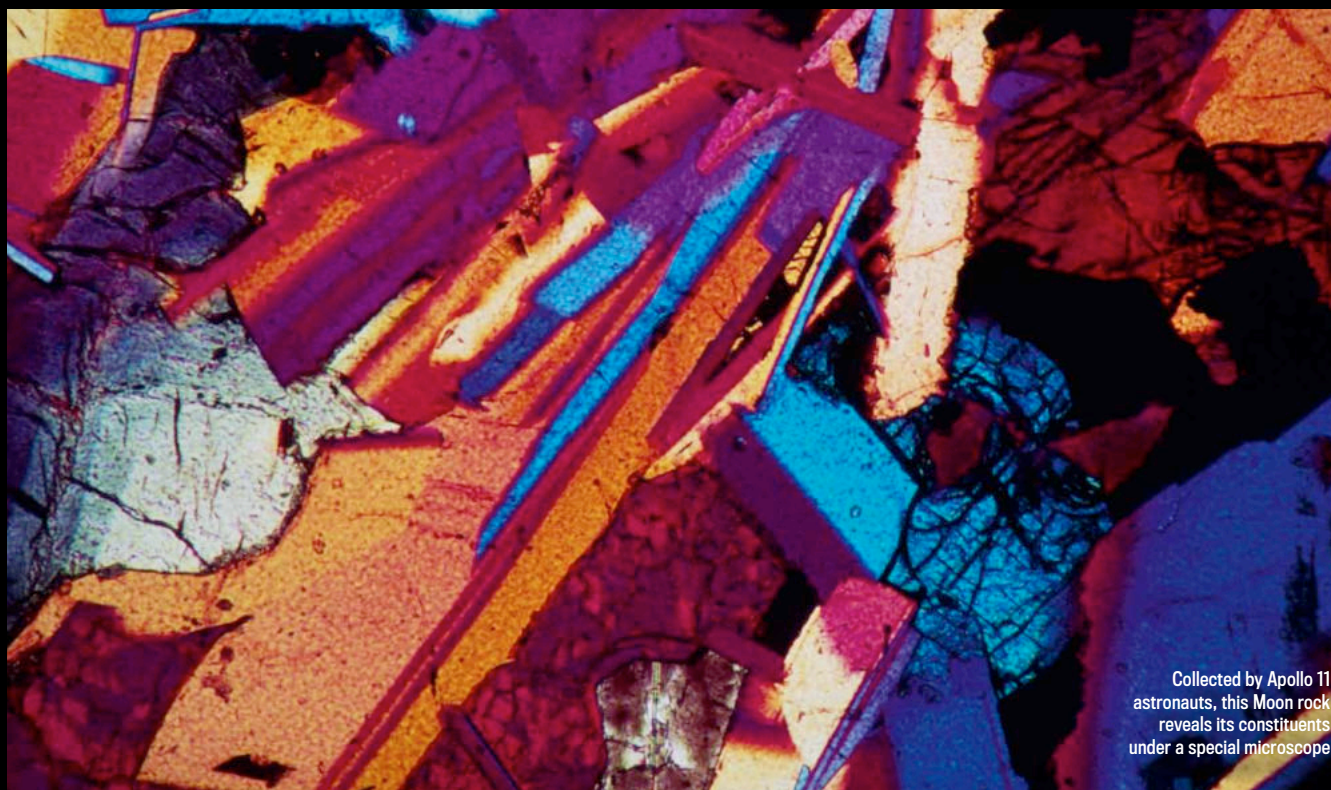
them, but a variant on the theory suggested that the Moon evolved in an orbit very close to Earth's own, and so the capture was a slow, gradual affair.

Urey's theory influenced NASA during the early planning of the Apollo programme, but so did the rival ideas of astronomer Gerard Kuiper. Kuiper revived the idea that the Moon had formed alongside Earth, showing how many of the problems due to the Moon's large size could be overcome.

A third theory went almost unnoticed in the clash between Urey and Kuiper. In 1946, Canadian

### THE KEY EXPERIMENT

Until the lunar landings from 1969–1972, there were several competing theories about the Moon's origins. Once NASA got its hands on some Moon rock, everything changed



Collected by Apollo 11 astronauts, this Moon rock reveals its constituents under a special microscope

When Apollo 11 returned 22kg of rocks to Earth on 24 July 1969, NASA's Lunar Sample Preliminary Examination Team wasted no time in getting them into the lab. The 15-strong team was led by geochemist Stuart Ross Taylor, and included leading geologists, physicists and microbiologists. Aside from careful visual inspection, the most important

analysis came from mass spectroscopy. This involved evaporating rock samples with an arc of electricity and splitting the resulting light to look for chemical 'fingerprints' – light emitted at specific wavelengths by different elements. As well as the precious lunar samples, the team kept a wide variety of Earth rocks on hand for comparison.

Work on the samples began on 26 July, and in early August the team released a preliminary report that showed the rocks contained relatively high concentrations of high-melting-point elements such as titanium, yttrium and zirconium, but low amounts of volatile elements such as sodium, potassium, lead, nickel and cobalt. It already

seemed clear that some heating process had diminished the elements with melting points lower than around 1,500°C. While this first report concluded that the balance of evidence favoured a double-planet theory, in reality it was pointing the way towards the giant impact hypothesis that would rise to prominence in the following decade.



geologist Reginald Aldworth Daly had suggested a twist on Darwin's fission idea. Instead of relying on a rapidly spinning Earth, he proposed that a major impact into the young Earth from another planet-sized body could have supplied enough energy to eject the material that formed the Moon. But despite Daly's reputation as a geologist, his musings on lunar origins were largely disregarded.

## AFTER APOLLO

By the time Apollo 11 blasted off for the Moon in 1969, settling the dispute between the rival co-accretion, fission and capture hypotheses had become one of the Apollo programme's key scientific aims. The six manned lunar landings were deliberately targeted at areas of the Moon whose geological history was likely to be very different, and in total some 382kg of lunar rock was returned to Earth for analysis.

Each of the major theories had its own implications for the composition of lunar rock and the Moon itself. If the Moon formed alongside the Earth, or if the fission hypothesis was correct, twin bodies with very similar compositions would be created. A captured Moon, on the other hand, might be very different in its chemistry and mineralogy. If the Moon formed at the same time, or was captured, it would probably be a 'differentiated' satellite, with internal layers and a dense iron core. But if it came from Darwin's fission idea it might not be, since the material to form the Moon would come from relatively lightweight mantle rocks.

As the geologists got to work, they found the composition of lunar rock samples was an intriguing mix of the familiar and the unknown (see 'The Key Experiment', left). Basalt rocks from the Sea of Tranquillity turned out to be heavily depleted of volatiles (see p93) compared to those on Earth, but otherwise mineralogically very similar. But what was most surprising was the widespread presence of the igneous rock anorthosite, and glass-like vitrified olivine. Both these and the lack of volatiles suggested the young Moon's surface had been hot enough to develop an ocean of liquid magma.

In the early 1970s, supporters of the three main competing theories struggled to explain the Apollo data, but still none entirely matched the new evidence. Fortunately,



## CAST OF CHARACTERS

The scientists who laid the foundations for our current understanding of the Moon's history



**George Darwin**  
(1845–1912)

The fifth child of Charles Darwin, George became a respected mathematician and astronomer in his own right. Although chiefly remembered today for his fission theory of the Moon's formation, he also did important work on the origins of tidal forces and the 'three body problem', describing the gravitational relationships of the Earth, Moon and Sun.



**Reginald Aldworth Daly**  
(1871–1957)

This influential Canadian geologist began his career studying rocks along the US–Canadian border. His invention of the giant impact hypothesis is often overshadowed by his contributions to our understanding of igneous rocks and his support for the theory of continental drift.



**Harold Urey**

(1893–1981) This US chemist made a name early in his career with the discovery and isolation of deuterium, the heavy isotope of hydrogen, and went on to play an important role in the development of the atom bomb. As well as promoting the capture hypothesis of lunar origins, he is famous for experiments with Stanley Miller that investigated the origins of life on Earth.



**Gerard Kuiper**  
(1905–73)

Dutch-born Kuiper was one of the 20th Century's leading planetary astronomers, discovering moons of Uranus and Neptune and first identifying carbon dioxide in the atmosphere of Mars. He was an influential figure at NASA during the first wave of interplanetary space probes, and helped select the Apollo lunar landing sites.



**William K Hartmann**  
(1939–) and **Donald R Davis** (1939–)

Hartmann and Davis are two of today's most respected planetary scientists, not least due to their involvement in the giant impact hypothesis. Hartmann [pictured] is concerned with the evolution of planetary surfaces, while Davis works mostly on the evolution of the Solar System's smaller bodies.

## TIMELINE

How our understanding of the Moon's origins has evolved over three centuries



Pierre-Simon Laplace's early explanation for the origins of the Solar System offers the first scientific theory of the Moon's origins. This is known today as the **co-accretion hypothesis**.

1795

1878

George Darwin puts forward his theory that the Moon split apart from a rapidly spinning young Earth, an idea derived from his mathematical research into tidal forces. This becomes known as the **fission theory**.



Harold Urey publishes the first serious arguments that the Moon may have originated elsewhere in the Solar System and been **captured into orbit** around Earth at a later stage.

1952

1975

William K Hartmann and Donald R Davis suggest that a giant **planetesimal impact** on the early Earth could have provided the energy to eject material to form the Moon.



A conference in Kona, Hawaii discusses the origins of the Moon and reaches consensus around the **giant impact hypothesis**, settling the debate. Many details are still to be resolved, however.

1984

➔ an overlooked alternative was waiting in the wings – Daly's giant impact hypothesis. Daly's idea returned to the spotlight in a 1975 paper by William K Hartmann and Donald R Davis of the Planetary Science Institute in Arizona.

By this time the resurrection of Laplace's nebular hypothesis was in full swing, thanks largely to the work of Soviet astronomer Victor Safronov. Safronov's twist on the Laplace theory included a stage in which the early Solar System was littered with 'planetesimal' bodies ranging in size from hundreds to thousands of kilometres across. Collisions between these formed the planets, and Hartmann and Davis were intrigued by the possibility that impacts by some of the smaller planetesimals onto the young Moon might have created the huge impact basins on its surface. Unaware of Daly's earlier suggestion, they also hit on the idea that a larger planetesimal striking Earth could have powered a fission-like process, flinging a blend of rocks from Earth and the impacting body into orbit.

A year later, Alastair GW Cameron and William R Ward of the Harvard College Observatory suggested an impactor the size of Mars that struck the Earth at a shallow angle. This would ensure that the majority of ejected material came from Earth's mantle, explaining the low density of the Moon compared to the Earth, and generate enough heat for most of the volatiles to escape into space.

Hartmann and Davis' theory dovetailed neatly with evidence from the Apollo missions, and gathered scientific momentum over the next decade. At the same time, the 'big three' theories were increasingly undermined by geological analysis and computer modelling. However, the complex nature of the Apollo results left plenty of room for debate, and it wasn't until a 1984 conference at Kona, Hawaii that the idea really took hold.

## THE MOON TODAY

Since the late 1980s, evidence that the Moon formed from material flung off in a giant impact has been mounting. Computer models have allowed the mass of the incoming body, the young Earth and the ejected material to be estimated, and in 2000 geochemist Alex Halliday even gave the impactor a name – Theia, after the mother of



## NEED TO KNOW

A glossary of scientific terms relevant to lunar history

### 1 ISOTOPES

Two or more forms of an element that share the same chemical properties but have different atomic masses. The relative mix or 'isotopic ratio' found for particular elements varies widely across the Solar System, so this provides a useful clue as to where materials came from.

### 2 PLANETESIMAL

A large body formed early in the history of the Solar System, with enough gravity to pull in gas and dust from the surrounding solar nebula and undergo rapid growth. Collisions between planetesimals are thought to have played a vital part in forming the planets.

### 3 VOLATILE

A chemical compound or element with a relatively low melting point that can be easily melted or evaporated by geological processes. The precise boundary between volatiles and high-melting-point substances varies depending on the context, but in lunar geology, volatiles include metals with melting points below 1,500°C.

the Moon goddess Selene in Greek mythology – which seems to have stuck.

Theia is just one of a number of large hypothetical planetesimals that may have roamed the Solar System in its early days. For obvious reasons, it has exerted a peculiar fascination for astronomers and a considerable amount of effort has been spent on investigating its potential properties. But, disconcertingly, as geologists have continued to learn more about the composition of the Moon, astronomers have once again been forced to revise the hypothesis in order to explain the mineral evidence.

It's now clear that the Moon is not as dry as once thought, and that the water locked into some of its minerals is unlikely to have been dumped there by comets. The idea of a global magma ocean is no longer tenable and models must instead allow the Moon to coalesce without melting all the way through. The isotopic ratios of certain

NASA chiefs pose with the first crate of lunar samples returned by Apollo 11 in 1969



minerals, meanwhile, are unnervingly similar to those found on Earth, with no signs of a contribution from the supposedly alien Theia.

Three possible tweaks to the theory have emerged to explain these problems. One is that Theia evolved in the same part of the solar nebula as Earth itself, and therefore had near-identical chemistry. It may even have orbited Earth until it grew too massive and unstable. A second idea is that Theia was much bigger than previously suspected – perhaps twice as massive as Mars – and so its impact substantially modified Earth's own chemistry. The third is that Theia was a stray ice dwarf world from much further out in the Solar System. Its impact provided large amounts of energy to eject rock from Earth's mantle, but its own volatile material evaporated away into space and it contributed little to the Moon's eventual composition.

Despite these problems, it is clear that the giant impact hypothesis still provides by far the best explanation for the properties of the Moon as we see it today. It may need further amendments, but we've come an awfully long way in our understanding of our nearest cosmic neighbour. ■

Giles Sparrow is a science writer and the author of books including *The Universe In 100 Key Discoveries* (Quercus, £19.99)

#### Find out more

4 Melvyn Bragg and guests discuss the origins, science and mythology of the Moon in *In Our Time* <http://bbc.in/LF4ces>

#### The Moon Forms

Clips from BBC science programmes on the Moon's origins: <http://bbc.in/r0d21u>

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# TO DO LIST

PLAN YOUR MONTH AHEAD WITH OUR EXPERT GUIDE

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-  WATCH
-  LISTEN
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-  PLAY
-  READ

## PICK OF THE MONTH



For more from Alice on *Ice Age Giants*, listen to our podcast at [sciencefocus.com](http://sciencefocus.com)



### Ice Age Giants

Alice Roberts investigates life on Earth during the Ice Ages

→ ALICE ROBERTS STRIDES into the distant past, looking very much like Indiana Jones. Back when ice covered large areas of the planet, it was roamed by creatures like *Smilodon fatalis* – the sabre-toothed cat. And Professor Roberts isn't satisfied with a big scary skull and some CGI predators. As an anatomist she wants to know how sabre teeth managed to kill their prey without snapping off their long, fragile canines. So she's off to find a scientist who's measured how far they can open their jaws and compared their skull anatomy with lions and cheetahs.

This series brings in researchers who study ancient sloth droppings, marks on rocks and the diseases that deformed fossilised bones to back up the reconstructions of Ice Age Earth with some convincing science. So for once, the CGI mammoths, giant sloths and sabre-toothed cats aren't the most exciting part of the programme. Instead, it's the thrill of discovery that glows in the conversations between Alice and the researchers.

"It's a great time to be doing a series like this," she says. "There are lots of different strands of evidence coming together to help us answer questions about how these animals lived, the kinds of environments they lived in and why they died out."

Some very odd beasts emerge from prehistory. Take Alice's favourite, the glyptodon. "I keep coming back to it – there's nothing quite like it. It was bizarre armadillo-like creature from Arizona which could grow to the size of a VW Beetle."

But we'll also meet our own ancestors, hunting mammoth and doing whatever it took to survive one of the planet's chillier periods without the benefits of central heating. It certainly puts the long, harsh winter in perspective...

**TIMANDRA HARKNESS**



*Ice Age Giants* will be shown on BBC Two in May – see *Radio Times* for further details

## DON'T MISS!



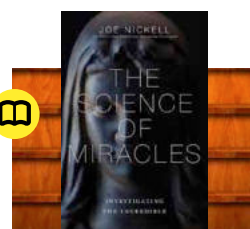
### Cheltenham 2013

This year's science festival is bigger than ever, with a host of famous names set to appear. **p96**



### Mammoth task

The teams of scientists racing to clone a woolly mammoth from frozen prehistoric DNA. **p98**



### Wonders on trial

We review a new book that assesses the evidence for miracle claims, from healings to stigmata. **p102**





# VISIT

EVENTS & EXHIBITIONS

WITH JHENI OSMAN

4-9 JUNE

## Cheltenham Science Festival

To book, call 0844 880 8094 or visit [www.cheltenhamfestivals.com/science](http://www.cheltenhamfestivals.com/science)

AFTER OUR ATTEMPTS at frog dissection during our school days typically ended badly for the odd finger, these days most of us are better off in the audience watching the pros at work. In 'Anatomy Live', Professor Alice Roberts will keep her fingers clean by carrying out live full-body MRI scans, 'slicing' bones, brains and hearts apart.

Other big names are also back at Cheltenham, including physicist Professor Jim Al-Khalili, discussing quantum biology, and Dr Kevin Fong, exploring how medical professionals work in the most extreme environments on Earth. And there are some truly legendary names at this year's festival, such as the man who started the whole does-it-exist-or-doesn't-it subatomic particle hunt, none other than theoretical physicist Professor Peter Higgs. And don't miss a trip through space with Dame Jocelyn Bell Burnell, who played an important role in one of the 20th Century's most important astronomical breakthroughs – the discovery of pulsars.



# WIN!

We've got over £400 worth of tickets to events at Cheltenham Science Festival to give away. See [bit.ly/cheltenhamcomp](http://bit.ly/cheltenhamcomp) to enter

## FOUR OF THE FESTIVAL'S FINEST



5 JUNE

### Peter Higgs In Conversation With Dara O Briain

Wed 5 June, 8.30pm, EDF Energy Arena, £15

YOUR CHANCE TO meet Peter Higgs himself as he talks to Dara O Briain about his inspiration, his life's work and how he felt when CERN's Large Hadron Collider finally confirmed his theory.



7 JUNE

### The Ugly Animal Preservation Society

Fri 7 June, 8.30pm, Crucible, £10

PANDAS AND TIGERS are the poster boys of conservation. Isn't it time less attractive creatures got a look in? Why not the naked mole rat or Purcell's hunter slug? Comedians and scientists battle it to decide which animal will become the society's mascot.



7 JUNE

### The Science Of Tea

Fri 7 June, 8.30pm, Pillar Room, £12

WE'VE HEARD MAKING a good cup of tea described as an art form, but we think of it as a science. Chemist Andrea Sella and materials scientist Mark Miodownik agree. They explain the chemistry behind the perfect brew, and provide the definitive answer as to whether milk should go in before or after the tea.



8 JUNE

### Controlling The Mind And Slicing The Body With Light

Sat 8 June, 10.30am, Pillar Room, £8

IN THIS *Focus*-sponsored event, neuroscientist Mark Lythgoe shows how the mind can be controlled by light. There'll even be hands-on demonstrations, with a live video link to the imaging labs at UCL.



**FROM 16 MAY**

## Sci-Fi Movie Night

Royal Observatory, London, 6.45pm, £7, £5 concessions/child, [www.rmg.co.uk](http://www.rmg.co.uk)



SINCE CURIOSITY PROVED the conditions for life once existed on Mars, we've been betting on what that alien life might have looked like – little green men are so 20th Century! Tweet us your ideas... and for inspiration, catch a series of SF classics at the Royal Observatory. Screenings include *Invasion Of The Body Snatchers*, *The War Of The Worlds*, *Invaders From Mars* and *The Day The Earth Stood Still*.

**17-18 MAY**

## International Astronomy Show

Warwickshire Exhibition Centre, [www.international-astronomy-show.com](http://www.international-astronomy-show.com)



IF YOU KNOW your equatorial-mounted scope from your altazimuth, then chances are you'll have already heard of this new show through the astro-net. But if not, this is the UK's largest astronomy show outside of London. With 40 astronomy specialists under one roof, and talks from the likes of *The Sky at Night* presenter Chris Lintott, it looks set to be out of this world...

**23 MAY - 2 JUNE**

## How The Lights Get In

Hay-on-Wye, <http://howthelightgetsin.org/>

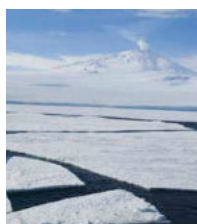


THIS ISN'T THE next dodgy sequel to *Twilight: Breaking Dawn*, but the title for this year's literature and philosophy festival at Hay-on-Wye. On 26 May at 10.30am, biologist Rupert Sheldrake, neuroscientist Colin Blakemore and novelist Joanna Kavenna discuss whether the human body is a machine. And for Terry Pratchett fans, on 4 June at 2pm the novelist discusses whether fantasies are central to how we perceive the world.

**30 MAY**

## Mt Erebus: Understanding The World's Southernmost Active Volcano

Darwin College, Cambridge, 1pm-2pm, <http://talks.cam.ac.uk/talk/index/41506>



'VOLCANOLOGIST' IS ONE of the world's most dangerous jobs: eight have been killed in the last 20 years. In this talk, Yves Moussallam from the University of Cambridge reveals the techniques he used to delve into the plumbing that feeds the lava lake inside Mt Erebus in Antarctica.

## SPEAKER OF THE MONTH

**MAY**


## Robin Ince

For tour dates and venues see [robinince.com](http://robinince.com)

### Who is he?

Robin is an award-winning comedian and writer, most famous for co-presenting Radio 4's *The Infinite Monkey Cage* with Mr Science Royalty himself, Prof Brian Cox.

### What's his background?

He started out as a comedy writer, moving into stand-up alongside the likes of Ricky Gervais at the Edinburgh Fringe. *The Infinite Monkey Cage* kicked off in 2009.

### What's he up to at the moment?

Robin's tour bus does a fair few miles every year, and in May he's clocking up 16 venues. The 'Importance Of Being Interested' tour salutes Robin's science heroes, Darwin and Feynman, and there are also pub facts that will rouse even the most trivia-jaded.

**6 JUNE**

## Making Livings: Why Darwin's And Wallace's Theories Were Worlds Apart

Natural History Museum, London, time TBC, [www.nhm.ac.uk](http://www.nhm.ac.uk)



THE 19TH CENTURY'S two top naturalists were like chalk and cheese, both in their personalities and in their theories. In this talk, Jim Moore, Professor of the History of Science at the Open University, dismisses the idea that Darwin stole the limelight while working from Wallace's research.

**7 JUNE - 15 SEPTEMBER**

## Visions Of The Universe

National Maritime Museum, London, £8, [www.rmg.co.uk](http://www.rmg.co.uk)



GALILEO IS OFTEN credited with inventing the telescope, but it was Flemish spectacle maker Hans Lippershey who first placed lenses at either end of a tube. Realising the new device's potential to spot a distant army, Galileo created his own – but when he turned it skywards, he saw the rings of Saturn for the first time. This exhibition tells the story of astro-imaging from the earliest drawings to the Hubble Space Telescope.



# WATCH

TV, DVD, BLU-RAY & ONLINE

WITH TIMANDRA HARKNESS

MAY TBC

## Human Swarm

Channel Four, May, dates/times TBC

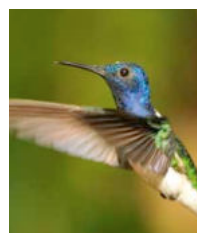


IN WARM WEATHER we buy more ice lollies; in cold weather, more soup and pies. So far, so obvious. But with an ever-rising tide of data available on everything from our shopping habits to the words we use on Twitter, those with access to the information are getting far more sophisticated in their predictions. In this two-part series, Jimmy Doherty follows the data trails we all leave, and meets the people tracking us: supermarkets, energy companies and air traffic controllers.

9 MAY

## How Life Works

Eden, starts 9 May, 8pm



WE CAN LOOK at life in extraordinary detail today, dissecting plants and animals down to the cell and even the individual molecule. But it's impossible to understand how life has successfully colonised the most remote and hostile corners of the planet without looking at the bigger picture. This four-part series unpicks the connections that hold the web of life together, revealing why grasslands need elephants, Brazil nuts need rodents and turtles need sponges. And no, it's not to keep their shells shiny.

11 MAY

## Mammoth: Back From The Dead

National Geographic, 11 May, 8pm



JURASSIC PARK IS pure fiction. No dinosaur DNA has survived in anything like a cloneable state. But a mammoth? Some scientists think 10,000 years is too soon to say 'gone forever'. Follow an international team racing to find a perfectly frozen mammoth cell in the Siberian tundra before taking it to a lab in Seoul, South Korea. But that's just the start. Next, they have to isolate the DNA itself. Spielberg eat your heart out.

TIMANDRA HARKNESS is a stand-up comedian and a presenter on BBC Worldwide's YouTube channel Head Squeeze

EDITOR'S CHOICE



Liz Bonnin and the Bang Goes The Theory team come to Eden this month

13 MAY

## Pop Science

Eden, starts 13 May, 7pm

➔ A FORTNIGHT OF fun science, first seen on the BBC, starts with Greg Foot's *Secrets Of Everything*. No question is too big or too daft for this guy, so this series puts his daredevil credentials to the test, as if to prove that health and safety concerns have not yet put a stop to every risky stunt science can dream up. He finds out, for instance, whether a passenger in a plummeting lift could survive by jumping at the moment of impact, and whether a coin thrown off the Empire State Building could kill you.

Less terrifying queries include why the sky is blue, and the old chestnut about whether you could shift the Earth's orbit by having the entire human race jump at the same time. Sadly the budget for that one

didn't quite stretch to the entire human race, so poor old Greg had to make do with measuring the seismic impact of the moshpit at Reading Festival.

Next, the latest series of *Bang Goes The Theory* gets a re-run, with Liz Bonnin, Jem Stansfield, Yan Wong and Maggie Philbin seeking out the science and technology that surrounds us. If you're still wondering whether Wi-Fi is bad for your health, or why dogs are good for it, sit back and let the team do the hard work on your behalf.

A highlight of this series of *Bang* is undoubtedly Jem pedalling a human-powered aeroplane into the sky, proving that Greg Foot can't afford to rest on his laurels when it comes to creating adrenaline-packed science television.



12 MAY

## Lift Off

National Geographic, 12 May, 8pm



FROM *PAC-MAN* TO the Walkman, and from MTV to Apple, the '80s were a revolutionary decade for entertainment technology. This documentary lets key figures like Steve Wozniak, Jane Fonda and Larry Hagman – JR in iconic soap *Dallas* – tell stories about how the foundations of today's multimedia world were laid. Part of National Geographic's 'The 80s: The Decade That Made Us' season.

15 MAY

## Voyages Of Construction

Eden, starts 15 May, 9pm



WITH ACCESS TO some of Britain's most sensitive engineering projects, this series lets you peek into workshops that not many people see inside. First up, a nuclear submarine: a project so secret that parts of the film have to resort to graphics, yet dependent on a huge team of people from Commander Paul Knight to 19-year-old apprentice Erin Browne. Later episodes feature defence contractor QinetiQ, which is working on bomb-defusing robots, and the aircraft engines made by Rolls-Royce.

16 MAY

## Killer Thursdays

National Geographic Wild, starts 16 May, 8pm



AM: Gave a mountain lion a shoeing. PM: Made snow angels. Great day.



**FRUSTRATED AT WORK?** Annoyed with your family? Enjoy some cathartic animal violence in the wildlife equivalent of *Celebrity Deathmatch*, thinly disguised as zoology. Hyenas are not the cowardly scavengers of legend – in fact, their ferocity starts soon after birth as they attack their own siblings. Wolves hunt more co-operatively, but will face down other predators, as one mountain lion discovers. But the series begins with a watery fight to the finish: killer whale vs shark!

## DVD & BLU-RAY



### Chasing Ice

Dogwoof, £10.25

MISSED THIS SPECTACULAR glacial saga on television? Buy it on DVD and watch the shifting patterns of ice across the globe as many times as you wish. National Geographic photographer James Balog's Extreme Ice Survey used 25 time-lapse cameras, and the resulting film won a Best Cinematography award at the Sundance Film Festival.



### Rise Of The Continents

2Entertain, price TBC

IN THIS BBC series, Professor Iain Stewart traces the transformation of the Earth from one primordial mass into the continents of today. The forces that shaped them usually work too slowly for us to see, but are powerful enough to raise the Himalayas and tear open the Atlantic Ocean.



### Industrial Revelations: Best Of British Engineering

Go Entertain, £14

COMEDIAN RORY MCGRATH explores the rich heritage of British engineering, from the Industrial Revolution to the jet engine. He finds technological marvels everywhere, even in Kew Gardens, but some have sadly vanished. Prepare to shed a tear for Concorde.

23 MAY

## North America

Discovery, starts 23 May, 9pm



THIS SERIES LOOKS at the diverse wildlife of North America. Rare and shy beasts such as the Mexican desert jaguar are captured on film, and crews brave Arctic waters to film a whale with her calf. Grizzly bears dive for salmon, bison roam the plains and sea turtles lay eggs on Costa Rican beaches. And for the bigger picture, time-lapse trickery condenses extreme weather into dramatic visual sequences.

JUNE TBC

## Extraordinary People

Channel 5, June TBC



A GROWN MAN who's less than a metre tall; a teenager who looks old enough to be her own grandmother. Four documentaries tell the stories of people facing rare medical challenges. Helen calls herself 'Incredible Hulk Woman', as a one-in-a-million condition causes her muscles to stiffen and tear inside her. And Tare's affliction is compounded by lack of medical facilities in her country, Zimbabwe.



# LISTEN

## BBC RADIO PROGRAMMES

WITH TIMANDRA HARKNESS

MAY

## Living World

BBC Radio 4, Sundays, 6.30am

THE NATURAL HISTORY series continues with topical reports from around the world. We can't predict where the presenters will be reporting from, or what they'll find, but we hope we can tune in to somewhere that's nice and hot.

6 MAY

## Tweet Of The Day

BBC Radio 4, 6 May



The Voice has a new ratings rival

NOT MORE BBC social media interactivity, but a charming and witty idea to bring birdsong into our lives. Each weekday morning for an entire year, a different bird will get its 90 seconds of fame. As well as the song itself, we'll hear about the singer from a narrator.

21 MAY

## The Truth And Nothing But The Truth

BBC Radio 4, 21 May, 11am

AS BRAIN SCIENCE progresses, the claims that our innermost thoughts can be revealed by science gain ground. The Royal Society's Brain Waves project claims to have revealed the 'neuro-signifiers' of lying

through brain imaging. Dr Geoff Bunn takes a personal look at the history of the lie detector. But can we believe everything he tells us?

29 MAY

## Vertical Farming

BBC Radio 4, 29 May, 9pm



Urban farms: a viable idea for the future?

AS CITIES GET denser and buildings rise higher, some argue that we should make use of new urban spaces to grow food. Ella McSweeney investigates whether this is a practical idea. Can we feed cities with food grown in cities, or are shepherds on skyscrapers just pie in the sky?

31 MAY

## The Truth About Mental Health

BBC World Service, starts 31 May

MADNESS IS FAR from being a universal concept. In different cultures, mental illness is treated - and defined - very differently. This series explores the reality of mental health around the world, including the challenges of responding to tragedies like the Norwegian massacre and children caught up in the Syrian conflict. But it's not all grim, as lower income countries find resourceful ways to tackle mental distress through traditional healers.



# TOUCH

## SMARTPHONE & TABLET APPS

WITH CHRISTOPHER PHIN



## The Particles

iPad  
Science Photo Library, £5.49

THIS APP HAS a stab at introducing the layman to the world of particle physics, but you get the feeling the author thought, 'To hell with this; I'm not going to dumb it down'. And that persists throughout as you explore quarks, bosons, mesons and baryons.

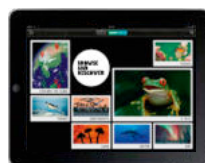
Happily, if you have a decent grasp of the basics, you'll enjoy reading this catalogue of fundamental particles. Terms are hyperlinked to a glossary, and there are plenty of animated diagrams. It could be prettier, but it's packed with crunchy information.



## TouchSurgery

iPhone, iPod Touch, iPad  
Kinosis Ltd, free

THOSE WITH A hankering to perform a little light surgery (perhaps medical students, or enthusiastic amateurs) can try it within the safety of this free app. In it, you're guided through a series of operations - an open appendectomy, say, or something simple (simple, they say!) like trochanteric wiring. You use the iPad's touchscreen to make incisions and more on a frighteningly realistic 3D model. It's fascinating stuff, but definitely not one for those with delicate stomachs.



## BBC Earth Wonders

iPhone, iPod Touch, iPad  
BBC Worldwide, £2.49

On one hand, this app is just a collection of over 500 photos and 50 short HD video clips culled from BBC series such as *Frozen Planet*, *Planet Earth* and the *Life*. But on the other hand, what's not to love about that?

Its navigation and grouping are a little haphazard, but there's a good amount of information here, and of course the photos and videos are stunning. It's nice they're overlaid with ambient natural sounds, but we wish the clips were longer. The 'Picture Of The Day' feature keeps you coming back.

CHRISTOPHER PHIN is the editor of *MacFormat* magazine





# PLAY

CONSOLE & COMPUTER GAMES

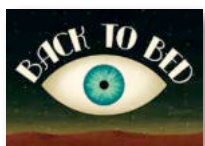
WITH NEON KELLY



## Metro: Last Light

PC, PS3, Xbox 360; Deep Silver; £39.99

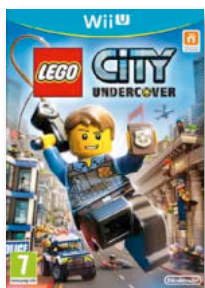
LIKE ITS PREDECESSOR, *Last Light* is based upon an underground Russian novel – ‘underground’ both in the sense that it was a cult favourite, and in that World War III has forced the remnants of humanity to live in old train stations. As horrifying as the prospect of the nuclear apocalypse may be, it’s a reliable backdrop for videogame escapism. *Metro* blends mutants, psychic hallucinations and political extremists, resulting in one of the bleakest first-person shooters you’ll ever play.



## Back To Bed

PC, iOS; Bedtime Gaming; Beta version currently free

IF YOU EVER encounter a sleepwalker, don’t wake them up. If you do, they’ll instantly die on the spot. Fine, so that urban legend isn’t actually true, but it still works as the setup for *Back To Bed* – a puzzle-based somnambulist rescue sim. Bizarrely, MC Escher and Dalí were key influences here, resulting in a dream-like landscape of floating stairs and chequered floors. Help Bob by placing objects in his path, steering him back to the safety of his mattress.



## LEGO City Undercover

Wii U; Nintendo; £39.99

PLASTIC BLOCKS MEET *Grand Theft Auto* in the Wii U’s first truly essential purchase. That might sound surprising to all you cold-hearted sceptics, but it’s true: this is a cracking game, and certainly not just for kids. It’s an open world cops and robbers outing with an emphasis on creative carnage, combined with a genuinely funny script. When you’re not smashing or building something, you’ll be spotting the not-so-subtle references to *Goodfellas*, *Die Hard* and *The Shawshank Redemption* – all performed by yellow polymer people.



EDITOR'S CHOICE

Nilin suddenly remembered that Bob hadn’t returned the copy of *Focus* she lent him

## Remember Me

PC, PS3, Xbox 360; Capcom; £37.99



➔ THE YEAR IS 2084, a date conspicuously chosen to serve as a nod-and-wink to George Orwell. France has fallen into the grip of a surveillance-obsessed corporation, and thanks to dubious technological advances, the authorities can monitor the memories of their citizens. Paris – or Neo-Paris, as it’s now known – still has the old recognisable landmarks, but with an added layer of *Blade Runner* grime. On the plus side, bread is still long, pointy and delicious.

Our heroine is Nilin, an acrobatic resistance member with a bad case of amnesia. As you explore the city and complete missions, you’ll recover slithers of her identity. Aside from advancing the story, these also unlock her forgotten martial art moves.

The latter can be arranged and strung together via the Combo Lab – a set of customisable button commands, allowing you to build your own *Matrix*-like fighting style, piece-by-piece.

Elsewhere the game explores Philip K Dick territory with sequences that allow you to hack into the minds of key characters. In one example you invade the brain of a security officer and change his recollection of a domestic argument. In the edited ‘memory’ the guard ends up killing his girlfriend; back in reality, he’s overwhelmed with guilt and promptly commits suicide. Cheery.

There’s a whiff of uncertainty hanging over *Remember Me*. The game has been in development for nearly five years but has largely lurked under the media radar, only receiving an official unveiling last August. This is Dontnod Studios’ first game, and the general lack of publisher fanfare might be cause for concern.

All the same, the game is looking very nice indeed, with polished graphics, and there are some fresh ideas here and original writing. Only time will tell if this is a sleeper hit underdog, or simply a forgettable failure.

NEON KELLY IS DEPUTY EDITOR AT VIDEOGAMER.COM



# READ

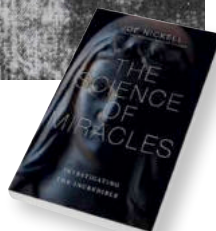
THE LATEST SCIENCE BOOKS REVIEWED

**H** Hardback **P** Paperback



Shrouded in mystery: religious artefact or medieval fake?

## The Science Of Miracles Investigating The Incredible



Joe Nickell

Prometheus **P** £16.99

THERE IS PROBABLY no-one in the world better qualified to write a book assessing the evidence relating to alleged miracles than Joe Nickell, Senior Research Fellow for the Committee for Skeptical Inquiry. Nickell brings a wide range of skills to the task including expertise in forensics, psychology, handwriting analysis and folklore. The result is an expert evaluation of the world's most famous miracle claims along with many lesser-known cases.

The book is divided into six sections dealing with, among other things, alleged miraculous healings, Hindu statues drinking milk and stigmata. It will probably come as no surprise to learn that Nickell does not find a single miracle claim that withstands critical scrutiny. Two chapters are devoted to assessing the authenticity of the Turin Shroud. As Nickell makes clear, the evidence overwhelmingly points to the shroud being a medieval European fake. Nickell has gone so far as to support his version of how the shroud came into being

by producing, with the assistance of a professor of organic chemistry, a replica.

Although I thoroughly enjoyed reading this book, much of the content was already familiar to me, as it would be to anyone who's read Nickell's previous books, such as *Looking For A Miracle* or *Entities*, or his regular column in *Skeptical Inquirer* magazine. The book would also have benefited from better editing: as each chapter is pretty much self-contained, there's quite a lot of repetition between them. It makes the reader very aware of the fact that this work is essentially just a collection of pieces that were written more or less independently.

Even so, this book is an excellent reference work that belongs on every skeptic's bookshelf.



**PROFESSOR CHRIS FRENCH** is Head of the Anomalistic Psychology Research Unit at Goldsmiths, University of London

### MEET THE AUTHOR



**Joe Nickell**

**You describe yourself as a 'miracle detective'. What does that involve?**

I'm trying to apply the techniques of detective work to the question of miracles, because so much of the controversy is between people who are very quick to accept miracles at face value or, on the other side, so-called 'debunkers' who think it's too silly for words. I look for the best evidence and let that lead me to a solution which I then adopt, like it or not. I believe that's the correct scientific approach.

**What's been your favourite miracle-related place to visit?**

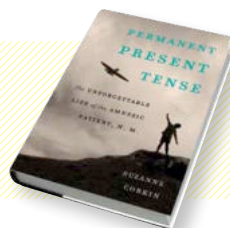
One very interesting place for me, and one quite close to home, was Conyers, Georgia where apparitions of the Virgin Mary were seen by a woman named Nancy Fowler on the 13th of each month. I was able to actually go there and get the goods, as it were. I looked into everything, and I believe Miss Fowler had what's called a fantasy-prone personality. She had a rich imagination and whatever she imagined seemed very real to her, but I think there was no evidence of any miracles at Conyers whatsoever.

**Have you received much hostility from religious groups?**

Well, I have had some moments! Once when I was with The Learning Channel, I was examining some rosaries at another site that were supposedly turning to gold. All of a sudden, somebody there said, "It's him!" and pointed at me. It was a scary moment because we weren't sure if the whole crowd was going to respond, but they were able to shush him and get me away from there.

**MORE ON THE PODCAST**  
Listen to the full interview with Joe Nickell at [sciencefocus.com/podcasts](http://sciencefocus.com/podcasts)





## Permanent Present Tense

**The Man With No Memory,  
And What He Taught The World**

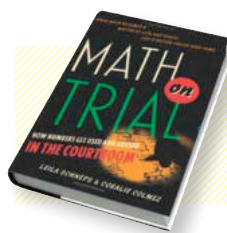
Suzanne Corkin

Allen Lane £20

ON 25 AUGUST 1953, Henry Molaison underwent experimental surgery aimed at halting his epilepsy. The result was catastrophic: from that day on, Henry never remembered a single experience for longer than about 30 seconds, living in an eternal present. Suzanne Corkin is one of a handful of neuroscientists who got to know Henry – though it was a sadly one-way business, because Henry was unable to recall people once they'd left the room. This first-person account of her work with HM, as he was known until his death in 2008, shows through revealing anecdotes how Henry's intellect and personality remained intact despite his devastating memory dysfunction. He remained able to complete quite tricky crosswords, for example, by adapting his pre-1953 knowledge, and was unfailingly polite to the researchers who tested and probed his mind on an almost daily basis. The case has already been written about widely, but Corkin's book adds intriguing details and puts HM into the broad context of neuropsychology, making it comprehensible for those without any prior knowledge of the field.



RITA CARTER is a science writer and the author of *Mapping The Mind*



## Math On Trial

**How Numbers Get Used And Abused  
In The Courtroom**

Leila Schneps and Coralie Colmez

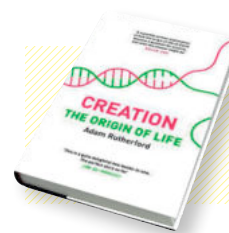
Basic Books £17.99

MATHEMATICS HAS A reputation for rigour and accuracy, but as this book explains, it can also be misleading and even manipulative. Using historical cases as examples, Schneps and Colmez reveal how mathematical misconduct can lead to wrongful convictions. Rather than opening with lengthy introductions to the theory, the authors dive right into the drama of the investigations, with key concepts emerging naturally as the stories unfold. The result has all the marks of a good mystery: tense conflicts, diverse characters and shock conclusions. We discover why probability theorist Ed Thorp turned up as a witness in a murder trial, and the difficulties of bringing DNA analysis into the Amanda Knox case. From treating related events as independent to collecting biased data, crucial mistakes are described with an impressive clarity.

Numerical errors are not unique to the courtroom: similar issues crop up elsewhere in life, which makes this book's message all the more important. Gripping and insightful, it successfully highlights the dangers of carelessly sprinkling mathematics over real-world problems.



ADAM KUCHARSKI has a PhD in Maths and is an award-winning science writer



## Creation

**The Origin Of Life/The Future Of Life**

Adam Rutherford

Viking £20

THIS IS A brilliantly-written and extremely well-informed account of two major areas of 21st Century biology. *Creation* is actually two books in one, as geneticist Adam Rutherford strictly divides his stories. 'The Origin Of Life' looks at key moments in the history of biology up to the present day, while 'The Future Of Life' takes us into cutting-edge laboratories to see the implications of their work in synthetic biology.

The future Rutherford describes is one of genetically engineered organisms that will deliver medicines, produce new fuels or protect space travellers from solar radiation. There is even the possibility of creating completely novel forms of life, using an entirely new genetic code called XNA. Rutherford is unashamedly enthusiastic about the potential of such developments, but not naïve – he clearly outlines the ethical issues and the dangerous potential for the weaponisation of GM organisms.

Clearly written, *Creation* is a real page-turner that explains how we got to where we are, where we are going and what might happen when we get there. Highly recommended.



MATTHEW COBB is Professor of Zoology at the University of Manchester



## Forecast

**What Physics, Meteorology  
And The Natural Sciences Can  
Teach Us About Economics**

Mark Buchanan

Bloomsbury £12.99

IN NOVEMBER 2008, an LSE professor was asked why his profession had failed to predict the global financial crisis. His response – that everyone thought they knew what they were doing – is unlikely to have impressed his interlocutor, the Queen. Her Majesty may get more satisfaction from a new analysis by physicist Dr Mark Buchanan, who argues that economists put too much reliance on idealised models, akin to viewing the weather as permanently wind-free and cloudless. What they should be doing, he argues, is exploiting current research into the behaviour of 'non-equilibrium' systems

such as earthquakes. This may not lead to precise predictions of the next bust, but it might reveal the danger signs.

Dr Buchanan's faith in the benefits of modelling is probably misplaced. Economic models are highly sensitive to the vagaries of human behaviour, and there's little sign of these being overcome any time soon. But he's surely right in pouring scorn on much of what economists have done over the last century or so.



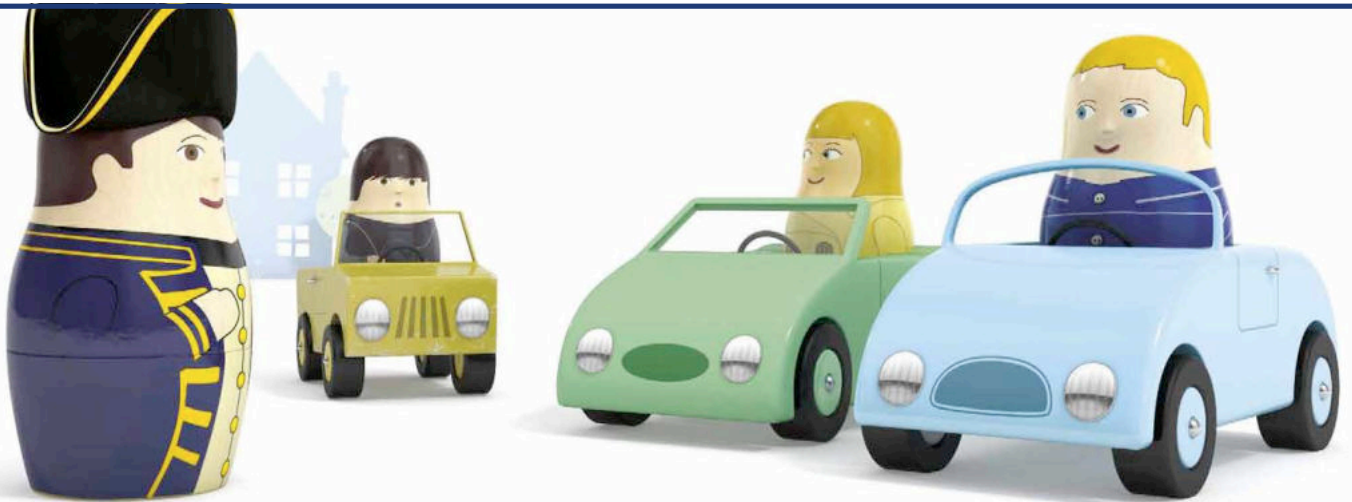
ROBERT MATTHEWS is a visiting reader in science at Aston University



.....

**MINDGAMES PUZZLE**  
**SOLUTION**  
No cheating! Don't look at this until you've attempted the puzzle on p111





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By Marian Ashcroft

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'Most people can be taught to write for publication,' claims Susan Metcalfe, Head of Britain's largest writing college, 'as long as they want to write, are willing to learn and put in the time and effort required. Our students prove that. They come from all walks of life and have very different educational backgrounds. Yet, after studying with us many will see their name in print for the first time.'

The Creative Writing course offered by The Writers Bureau covers all genres – articles, short stories, novels, books, scripts etc. so students get a chance to explore all types of writing to find where their interests and talents lie.

Students also receive individual, personal tuition from a professional writer who gives guidance on style, technique and marketing.

'The course gives a student confidence in their work and the know-how to increase their chances of publication,' explains Susan. 'Unfortunately, the untrained writer is more likely to have their work returned to them, not because they can't write, but because they haven't followed the rules of the publishing world. And that, in a large part, is what we teach – how to make your work acceptable to those who will pay for it.'

The college also provides a whole support system to novice writers that includes their tutors, their advisors, free resources and chance to converse with other writing students on their website.

The Writers Bureau is so confident in the training and support it provides that it gives an amazing money back guarantee – if a student doesn't earn their fees back through published writing by the end of their course the college will refund them in full. Plus, the course comes on 15-day trial so you can see for yourself the quality of the training on offer.

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**Tim Skelton** "Besides seeing my first book in print, I've appeared in The Times and The Independent, and updated yet more guide-books for Fodor's, Thomas Cook, and the AA. I am writing flat-out, and getting paid what I can now describe with pride as a decent salary. And it is thanks to The Writers Bureau that I got this chance. It provided me with the opportunity to realise an ambition which I didn't know how to nurture. I do now."

**Published**



**Anne Perdeaux** "This has been my first full year as a writer, and I am thrilled with my earnings at this stage – £1589.80 – especially as I'm still only half-way through the course. I love being able to tell people that I'm a 'freelance writer'. After 40 years of working I've finally found a job I love!"

**Published**



**Chris Green** "I've had 30 pieces of work accepted by various publications since I started my Writers Bureau course – a mere 18 months ago. I contemplate that fact and I am amazed to have come so far in such a short time. Thanks to the careful and patient tutoring provided by The Writers Bureau and the boundless confidence this has given me, I can continue to explore my potential and see where it takes me."

**Published**



**Lucy Costigan** "This course has so far been simply amazing and has given me the confidence to send in my work to several leading, glossy magazines. My tutor has given me fantastic support and brilliant feedback on every one of my assignments. I find it hard to believe that I have already had four articles published."

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CGC - 33 - 01, 25 Canada Square,  
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On the way home that evening I asked Peter how it was done. He said there was really nothing to it - simply a memory feat - and that anyone could develop a good memory by following a few simple rules. And then he told me exactly how to do it.

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**BBC Wildlife  
MAGAZINE**



# MINDGAMES

**BBC FOUR** Pit your wits against these brainteasers by David J Bodycombe, question-setter for BBC Four's *Only Connect*

## PRIZE PUZZLE

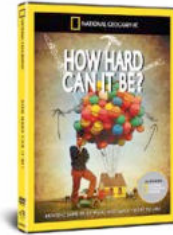
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Post your entry, marked 'Prize Puzzle 255', to: *Focus* magazine, PO Box 501, Leicester, LE94 0AA, to arrive by 5pm on 30 May 2013. We regret that we cannot accept email entries for this competition. See [sciencefocus.com](http://sciencefocus.com) winners for a list of previous winners and solutions.



See bottom of p104 for terms and conditions. Congratulations to Kathy Humphrey (Crewe), Andrew Holmes (Northumberland), Paul Sidney (London), Stephen Savage (London) and David Graham (County Antrim), who all answered our March Prize Puzzle correctly to each win a copy of *Africa* on DVD.

### Q1

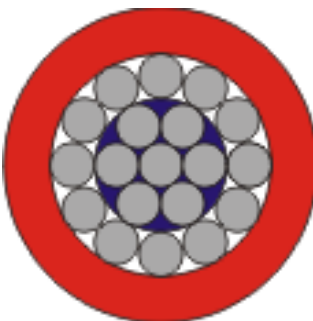
What is described as a quarter but actually looks like a half?

### Q2

If I put one letterhead and a blank continuation page into an empty printer randomly to print a two-page business letter, what is the probability that it would be printed correctly?

### Q3

How many of the small grey circles could fit into the red ring?



### Q4

Write one more letter onto this window so that the longest possible word can be read.



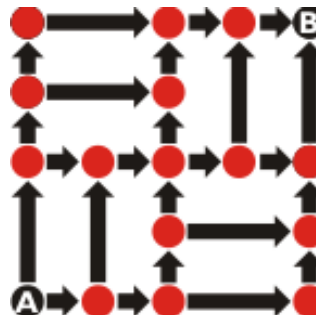
### Q5

Every row and column has something in common. Which letter should go into the yellow box?

Y	-	
T	M	-
+	L	K

### Q6

Following the direction of the arrows at all times, how many possible ways are there of getting from A to B?



### Q7

If you were to take an old, square crisp packet and re-seal it so that the corners of the open end now meet in the middle of that edge, what shape would you get?

### Q8

Move the listed cards into the grid so that the best possible poker hand in each row and column matches the label shown. The cards are not necessarily in the right order (e.g. 5-4-6-7-3 still counts as a 7-high straight).

4♥ 6♦ 6♠ 7♥ 8♥ 9♦ 9♠ 10♦ 10♥ Q♦  
K♦ K♥ K♠ A♦ A♥

J♠		8♠	A♠		FLUSH (all same suit)
J♥	6♥	4♣		6♣	ONE PAIR
		8♦	A♣		ONE PAIR
					FLUSH (all same suit)
J♦					ROYAL FLUSH (10 to Ace in same suit)

FULL HOUSE (pair + 3 of a kind)	FULL HOUSE (pair + 3 of a kind)	2 PAIR	2 PAIR	QUEEN HIGH (no pair)
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## SOLUTIONS

Q1) The first quarter (or last quarter) phase of the Moon happens when half of the surface is illuminated (to viewers on Earth).  
Q2) There is a 50:50 chance that page 1 is (a) on the correct side of the paper, the letterhead sheet. Hence the overall chance is 1/8.  
Q3) 18. After the centre circle, each ring can contain 6, 12, 18, 24, ... small circles.  
Q4) Add a backwards C to the start so that it reads AUTOMATIC from the other side.  
Q5) Every row and column contains 2 diagonal, 3 vertical and 2 horizontal lines. The top row and right column are missing one horizontal and two vertical lines, so H is the only possibility.  
Q6) 13 routes.  
Q7) A tetrahedron.  
Q8) See illustration on p104.

## QUICK QUIZ

Test your knowledge of stars

**Q1** .....

What's the closest known star to the Sun?

- a) Barnard's Star
- b) Proxima Centauri
- c) Wolf 359

**Q2** .....

Which of these isn't a type of star?

- a) White wanderer
- b) Blue straggler
- c) Yellow hypergiant

**Q3** .....

In approximately how many years will the Sun become a red giant?

- a) 5 billion years
- b) 15 billion years
- c) 25 billion years

**Q4** .....

Complete the sentence: "A pulsar is a rotating ....."

- a) Black hole
- b) White dwarf
- c) Neutron star

**Q5** .....

The 'Big Dipper' or 'Plough' is part of which constellation?

- a) Libra
- b) Andromeda
- c) Ursa Major

**Q6** .....

What's the maximum mass of a stable white dwarf?

- a) 0.4 solar masses
- b) 1.4 solar masses
- c) 2.4 solar masses

**Q7** .....

What's another name for the 'Seven Sisters' star cluster?

- a) The Pleiades
- b) The Hyades
- c) The Beehive Cluster

ANSWERS:

1b, 2a, 3a, 4c, 5c, 6b, 7a

YOU ARE:

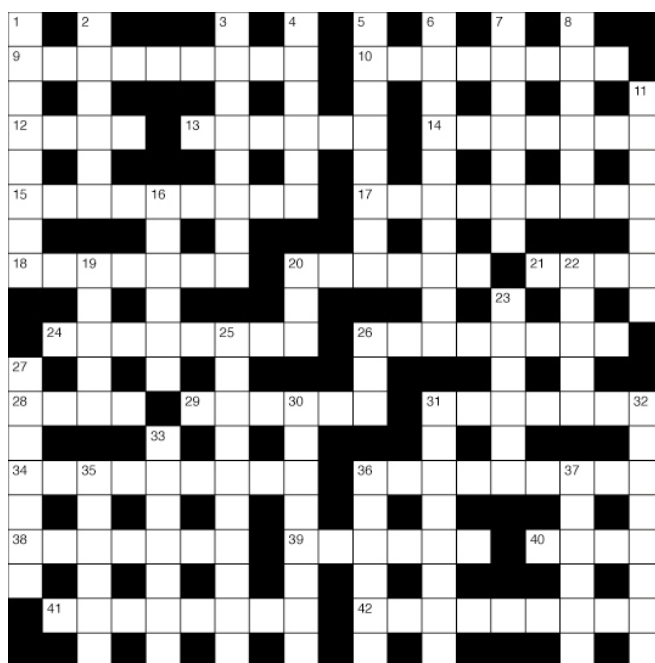
0-3 Seeing stars

4-5 Aiming for the stars

6-7 Flying through the stars

## FOCUS CROSSWORD No 151

EVERY MONTH, A NEW CHALLENGE  
SET BY AGENT STARLING



### ACROSS

- 9 Old flier to send us a report (9)
- 10 Bit of pressure on item (8)
- 12 Unusual not to be well done (4)
- 13 Motionless form of electricity (6)
- 14 Element of brie breaking down in the stomach (7)
- 15 Accelerator on unfinished bike returned to chap (9)
- 17 Lame baron broke part of skull (5,4)
- 18 Spasm is a neat development (7)
- 20 Moved in late, like ringworm (6)
- 21 Shellfish for Greek character - double helping (4)
- 24 Solve the price he'd set (8)
- 26 Rennin used, so my chin cleared up (8)
- 28 The end of the steak (4)
- 29 Turn to scheme to get daughter to higher ground (6)
- 31 Skirt gets quiet word at least (7)
- 34 Pressure gauge used by hand in Spain (9)
- 36 Pry about the new, strange flower (9)
- 38 Part of atom might turn one off (7)
- 39 Deal with one rant (6)
- 40 Mark's out of mascara (4)
- 41 South Africa has a gross form of seaweed (8)
- 42 Lizard crawled round each melon (9)

### DOWN

- 1 Rips lace to form an air hole (8)
- 2 Passenger ship not ultimately in charge of iron (6)
- 3 Care a bit about micro-organisms (8)
- 4 Sea god floating round Neptune (6)
- 5 Example of spice affecting soldiers (8)
- 6 Fairy trill performed by a butterfly (10)
- 7 Sign next to railway book store (7)
- 8 Developed in lab, only where pigment is missing (6)
- 11 Forgetfulness is a mean problem (7)
- 16 Noses about round island to find protein (6)
- 19 Some heat from the other machine (5)
- 20 Pitch to a sailor (3)
- 22 Part of a bone - I left one with hesitation (5)
- 23 Food for swan enthusiast (6)
- 25 The pony lost employment at the line (10)
- 26 Second-hand food contained copper, on the day (3)
- 27 Rob worked quarry to get an element (7)
- 30 Keys get share of purification (8)
- 31 Main ride is organised along a great circle (8)
- 32 Turning amber, men take cover (8)
- 33 Displeasure in the shade (7)
- 35 Learn about getting united concerning nerves (6)
- 36 I carp about unknown theft (6)
- 37 Firework found in the salad (6)

### SOLUTION TO CROSSWORD No 148

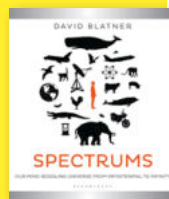
TG Price, AG Lockhart, Kathy Humphrey, M McKeown and Martin Smith solved issue 252's puzzle and each receive a copy of *National Geographic* 125th Anniversary on DVD.



### WIN! A COPY OF SPECTRUMS - OUR MIND-BOGGLING UNIVERSE, FROM INFINITESIMAL TO INFINITY BY DAVID BLATNER

The first five correct solutions drawn will each win a copy of *Spectrums* (Bloomsbury, £12.99).

Entries must be received by 5pm on 30 May 2013. See below for entry details.



## YOUR DETAILS

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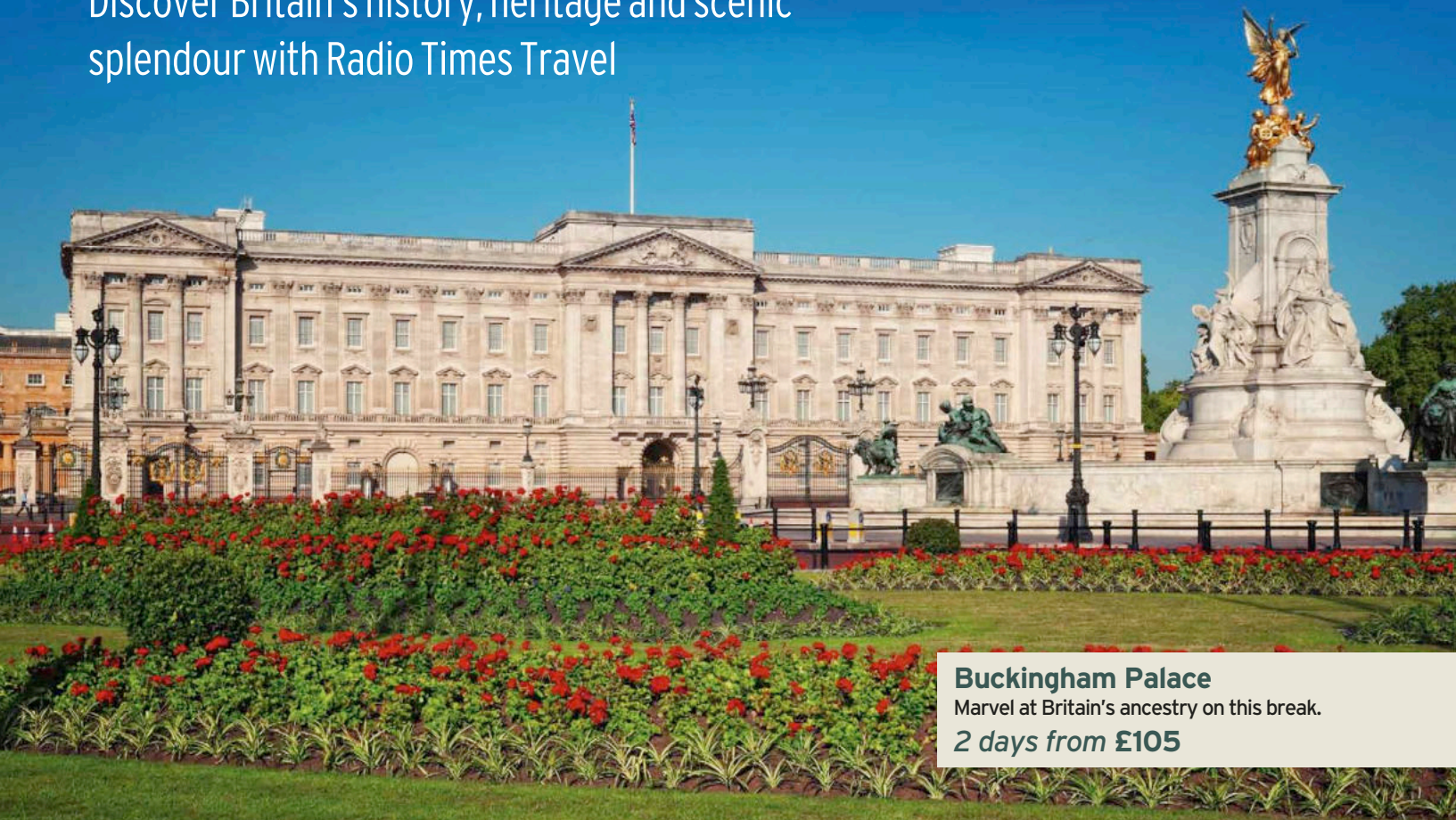
Post entries to Focus June 2013 Crossword, PO Box 501, Leicester, LE94 0AA or email a scan of the completed crossword or a list of answers to [june2013@focuscomps.co.uk](mailto:june2013@focuscomps.co.uk) by 5pm on 30 May 2013. Entrants must supply name, address and phone number. By entering, participants agree to be bound by the terms & conditions, printed in full on page 104. Immediate Media, publisher of Focus, may contact you with details of our products and services or to undertake research. Please write 'Do Not Contact' on your email or postal entry if you do not want to receive such information by post or phone. Please write your email address on your postal entry if you would like to receive such information by email.



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## INTO THE FUTURE

# STEPHEN BAXTER

**T**HE RECENT DISCOVERY of a planet in Alpha Centauri, the nearest star system to our Sun, has caused huge excitement. Alpha Centauri Bb is about the same size as Earth – though it doesn't share Earth's habitability, because it orbits so close to its parent star, Alpha Centauri B, that its daylight side is hot enough for rock to melt.

Nevertheless, if one planet exists in the Centauri system then there's a chance of more – and if the nearest star system of all hosts planets, then it seems likely that planets will be very common indeed across our Galaxy. But any planetary system circling Alpha Centauri must be very unlike our own, and face a very different future from ours.

Alpha Centauri is a triple star system. The two principal stars, known as A and B, are both similar to our Sun, Alpha Centauri A in particular. But whereas Alpha Centauri is 4 light-years from the Sun, these near-twin stars are no further apart than the planets in our Solar System.

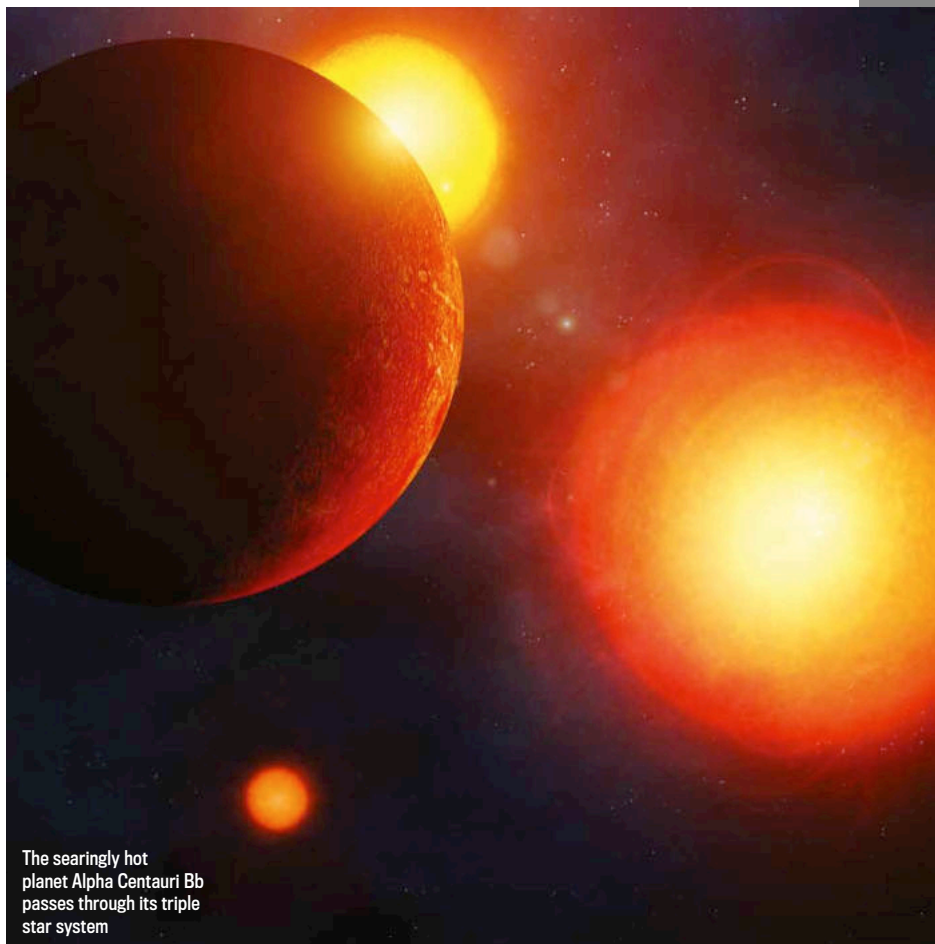
Proxima, the third star in the system, orbits the main pair 400 times further away than B is from A. Proxima is actually the closest star of all to the Sun, which is why it takes its name from the Latin for 'near'. Proxima is an unspectacular red dwarf: it's a minor component of this system but of great interest to astronomers, because while only a few per cent of the Galaxy's stars are like the Sun (or Alpha A and B), 70 per cent are like Proxima.

We used to think that multiple star systems couldn't develop planetary systems: scientists believed that the stars' gravitational perturbations would break up any protoplanets before they could stabilise. But more recent studies indicate that for planets as close to Alpha A as Earth is to the Sun, B's gravity would have no significant effect, and vice versa.

This theory seems to have been confirmed by the discovery of planet Bb. It seems unlikely that gas giants would form in such a system. But planets of A and B could well form within their stars' 'habitable zones' – that is, at a distance from the star that would allow liquid water to occur on the planet's surface, which is essential for life like ours. So Alpha Centauri may actually harbour twin planetary systems, even Earth-like worlds, just a few lighthours apart.

And if Alpha Centauri's present is exotic, its future is even more so. Astronomer Martin Beech of the University of Regina, Canada, has conducted numerical simulations of the evolution of the star system in the far future. Alpha A, the largest star, will age fastest as its hydrogen fuel is exhausted. Three billion years from now it will first

**“By the time Proxima enters its own old age, the glory days of the triple Alpha system will be nothing but a faint memory”**



The searingly hot planet Alpha Centauri Bb passes through its triple star system

swell up into a 'red giant' (as will our own Sun), then collapse back to become a 'white dwarf' with nearly half its mass lost. The swelling will be disastrous for life on any planets orbiting either A or B, and such will be the loss of mass that A and B will lose their gravitational hold on Proxima, which will detach itself from the system.

Somewhat later, Alpha B will similarly age and lose its mass, so that in about 12 billion years from now the two central stars A and B will also become uncoupled. The Alpha Centauri system we know today will be no more, with its three components following their own independent paths through the Galaxy.

But this is only the start of the story for Proxima. The modest red dwarf has a lifetime measured in trillions of years: that is, thousands

of billions. By the time Proxima enters its own old age, the glory days of the triple Alpha system will be nothing but a faint memory from the dawn of the age of cosmic star-making. ■

**STEPHEN BAXTER** is a science fiction writer whose books include the *Destiny's Child* series and *The Science Of Avatar*



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